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Physiological Responses to a Battling Rope High Intensity Interval Training Protocol

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by

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May 16 2013

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ABSTRACT

To investigate the aerobic/muscular endurance responses to a 4 week battling rope(BR) high intensity interval training(HIIT) protocol. 15 men/15 women(22±2yr) trained 3x/week, for 4 weeks. A 30 second maximal work interval (performing the exercise), alternating between the double-whip and alternating-whip exercises, separated by 60 seconds recovery for 10 work/rest rounds was used. Women used 40 foot, 1.5 inch, 20lb ropes and men used 50 foot, 1.5 inch, 25lb ropes. Following HIIT females increased VO2max(7.8%), average peak VO2 during HIIT(8.4%), pushups(36.4%), and situps(10.1%) and with no change in cadence or RPE. Males saw no change in VO2max and situps but increased pushups(11.1%), rope cadence(14%), and reduced RPE's(13.5%). Females and males were exercising at 80% of HRmax, had greater VO2's for double versus the alternating-whip exercises, and with peak blood lactate levels of 9.36 and 11.06mmol/L respectively. BR HIIT shows potential to improve aerobic/anaerobic parameters over 4 weeks and should include a progressive overload component.

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I would like to express my appreciation for the assistance of my fellow graduate students, Neil Pettit, Evan Brydges, Mark Oxford, Andrew Friesen and Jillian Ciccone. I would like to express my gratitude to my advisory committee, Dr. Rupp Carriveau, Dr. Kevin Milne and my direct advisor, Dr. Kenji Kenno for all of their assistance throughout my thesis and graduate school experience. I would like to thank Adrianna Duquette who dedicated ample time to preparing the lab for my data collection, among other things to help me prepare. Also, I would like to thank Dr. Nancy McNevin for her regular guidance with my statistical design.

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LIST OF ABBREVIATIONS, SYMBOLS, NOMENCLATURE

American College of Sports Medicine (ACSM)

Heart Rate (HR)

High Intensity Interval Training (HIIT)

Maximum Oxygen Consumption (VO2 max)

Volume of Oxygen/Oxygen Consumption (VO2)

Physical Activity Questionnaire Plus (PAR-Q+)

Ratings of Perceived Exertion (RPE)

INTRODUCTION

High intensity interval training (HIIT) is a form of cardio-respiratory training where a selected exercise, typically cycling or treadmill running, is performed for a specified amount of time (usually 1 min or less) followed by a specified rest/recovery interval, that may be less than, equal to or greater than the initial work interval (Helgerud et al., 2007; MacDougall et al., 1998; Tabata et al., 1996). This workout is then repeated for a specified number of work/rest intervals typically varying from 4-10 rounds (Laursen & Jenkins, 2002). When utilizing treadmills and cycle ergometers for HIIT, an exercising intensity of 80-170% of maximum aerobic capacity (VO2 max) or the running speed that corresponds to the participants VO2 max during the pre-test VO2 measurement is used to prescribe the work interval intensity (Laursen & Jenkins, 2002; Tabata et al., 1996). Also, the words “all out/maximal effort” can be used to describe the work interval intensity to the participant in an effort to reach 100+% VO2 max, without direct measurement (Laursen & Jenkins, 2002).

With HIIT, the work interval is followed by a rest/recovery period to allow regeneration of ATP and creatine phosphate stores as well to allow some of the accumulated muscle lactate from anaerobic glycolysis time to diffuse out into the bloodstream. High energy phosphate regeneration and the removal of lactate and it’s protons from muscle help reduce muscle fibre acidity thereby enhancing ATP availability through glycolysis for the next work interval (Plowman & Smith, 2008). Measuring blood lactate concentrations is one way to quantify the anaerobic intensity of the exercise as elevated lactate from anaerobic glycolysis corresponds to increases in exercise intensity

(Plowman & Smith, 2008). Blood lactate measurements are commonly measured pre and immediately post exercise and at 5, 10 and 20 minutes post exercise, to allow lactate time to diffuse from the working muscle and thereby get a better representation of intracellular lactate levels during the actual exercising period (Bayati, Farzad, Gharakhanlou & Agha-Alinejad, 2011; Ozturk, Ozer & Gokce, 1998).

HIIT has been shown to significantly improve VO2 max (Astorino, Allen, Roberson & Juancich, 2012; Driller, Fell, Gregory, Shing & Williams, 2009; MacDougall et al., 1998; Rodas, Ventura, Cadefau, Cusso & Parra, 2000; Tabata et al., 1996), cardiomyocyte dimensions (Kemi et al., 2005), ventilatory thresholds (Poole & Gaesser, 1985), cycle endurance capacity (Burgomaster, Hughes, Heigenhauser, Bradwell & Gibala, 2005), peak cycling power output (Tabata et al., 1996), increase aerobic enzyme activity (citrate synthase and cytochrome c oxidase and 3Hydroxyacyl-CoA dehydrogenase)(Hood, Little, Tarnopolsky, Myslik & Gibala, 2011; Little, Safdar, Wilkin, Tarnopolsky & Gibala,2010; Tremblay, Simoneau & Bouchard, 1994) and increase fatty acid oxidation capacity (Chilibeck, Bell, Farrar & Martin, 1998; Talanian, Galloway, Heigenhauser, Bonen & Spriet, 2007). Additionally, HIIT studies have reported significant increases in the anaerobic/glycolytic enzymes such as phosphofructokinase, aldolase, pyruvate kinase, creatine kinase and lactate dehydrogenase (Parra, Cadefau, Rodas, Amigo & Cusso, 2000). HIIT protocols have also resulted in significant increases in creatine phosphate (31%) and glycogen stores (32%) of the vastus lateralis skeletal muscle (Rodas et al., 2000). These results demonstrate an improved efficiency of aerobic and anaerobic ATP formation using

HIIT, resulting in an increase in the time to fatigue and an ability to perform at higher exercise intensities for longer periods of time (Rodas et al., 2000).

Generally, the aerobic/anaerobic metabolic improvements associated with HIIT have been reported over durations ranging from 2 to 15 weeks (Laursen & Jenkins, 2002; Tremblay et al., 1994; Rodas et al., 2000), consisting of 2 to 6 workouts a week (Chilibeck et al., 1998; Laursen & Jenkins, 2002; MacPherson, Hazell, Olver, Paterson & Lemon, 2011) with work to rest ratios ranging from 3:1 to 1:11 (Gosselin, Kozlowski, Devinney-Boymel & Hambridge, 2012; Laursen & Jenkins, 2002; Linossier et al., 1993). Numerous HIIT studies have demonstrated that in as little as 4 weeks, significant aerobic improvements such as increases in VO2 max and aerobic enzymes, can be seen (Astorino et al., 2012; Bayati et al., 2011; Driller et al., 2009; Jakeman, Adamson & Babraj, 2012; Laursen, Shing, Peake & Coombes, 2005; Rodas et al., 2000; Talanian et al., 2007). In regards to upper-body dominant HIIT, Driller et al. (2009) reported that 7 total rowing ergometer HIIT sessions over only 4 weeks also produced significant improvements in a rowing ergometer tested VO2 max (7.0±6.4%).

Burgomaster et al. (2005) also demonstrated that approximately 15 minutes of HIIT over only 2 weeks resulted in a significant improvement of 81-169% in time completed on a cycle endurance test (must maintain 40rpm at 80% VO2 max), making this type of HIIT while strenuous, very time effective. Burgomaster et al. (2008) also compared 40-60 minutes of continuous cycling at approximately 65% VO2 max, 5 days a week for 6 weeks to 4-6, 30 second sprints with a 4.5 minute break for 3 times a week for 6 weeks. Similar improvements in skeletal muscle oxidative capacity between HIIT and steady state training were reported but interestingly, the HIIT group performed 90% less total weekly exercise volume compared to the endurance group. This research demonstrates the greater time-efficiency of HIIT protocols compared to endurance protocols (Burgomaster et al, 2005; Burgomaster et al., 2008; Gosselin et al., 2012; Rodas et al., 2000). This may aid in long term exercise adherence by recreationally active individuals and competitive athletes.

Most HIIT programs are completed on a cycle ergometer or a treadmill which is designed to primarily train the large lower body (leg) musculature (Gibala et al., 2006; Little et al., 2010; NytrØen et al., 2012). The effects of HIIT on the upper body musculature have also been reported using rowers, swimmers and wheelchair participants. When rowers were high intensity interval trained on a rowing ergometer for 8, 2.5 minute intervals with a 70% maximum heart rate (HR) recovery interval for 7 times over 4 weeks they significantly improved their 2000 meter time trial by 1.9± 0.9%, 2000 meter power by 5.8±3% and relative VO2 max 7.0±6.4% when compared to a continuous training protocol over a total of 7 sessions, spanning 4 weeks (Driller et al., 2009). Magel et al (1975) tested the maximal swimming VO2 (using a swimming tether) of 15 recreational male swimmers pre and post 3 days a week of swimming HIIT (progressing from 50 yard to 200 yard sprints with a recovery to 70% of maximal swimming HR) for 10 weeks. They reported a significant improvement in aerobic capacity when tested again in the pool, but saw no difference when re-tested on the treadmill**.** Le Foll-de Moro, Tordi, Lonsdorfer and Lonsdorfer (2005) implemented a 6 week, 3 times a week wheelchair HIIT program (6 rounds of 1:4 minutes work:rest) on six subjects with recent spinal cord injury and saw a 36% improvement in VO2 max. A similar HIIT program was used by Maire et al. (2004) (6 rounds of 1:4 minutes work:rest) who tested 14 patients who underwent total hip arthroplasty, and reported a 13.5% increase in VO2 max compared to pre-surgery and control group values when utilizing arm ergometer HIIT. These upper body dominant HIIT investigations demonstrate that metabolic improvements can be seen in conditioning that strictly utilizes upper body musculature. Strength and conditioning professionals are utilizing different apparatuses to take advantage of these upper body adaptations associated with upper body dominant HIIT.

Recently, large diameter ropes (1-2 inches) weighing approximately 20 to 75 pounds called battling ropes have emerged as an alternative training apparatus for HIIT programs. Unlike cycle or treadmill HIIT which uses the leg muscles, battling ropes primarily utilize the upper body musculature (i.e. deltoids, biceps, triceps and forearms). Battling ropes are typically 40 to 50 feet in length and are anchored securely to the floor in the middle of the rope, creating two lengths of 20-25 ft. With knees slightly bent, the exerciser grasps the ends of the extended rope and moves his/her arms rapidly in an up and down motion with a vertical displacement of the rope. There are a number of exercises that can be done with battling ropes but two common motions are: both arms moving together called the “double whip” and both arms moving opposite to one another in the vertical plane called the “alternating whip” (see Figure 7 and 8).

In the only battling rope research abstract published to date, Fountaine, Adolph and Sheckler (2011) reported that during a single session of 15 seconds of a maximal double whip exercise and 45 seconds of rest, battling rope HIIT produced exercising heart rates that were 83% of age predicted maximums in 24.7±1.9 year olds and resulted in elevations in calculated caloric expenditure. Increasingly, many personal trainers and athletes are using battling ropes for HIIT protocols with the intention of enhancing aerobic and anaerobic fitness parameters, with no data to support its effectiveness as an aerobic/anaerobic or muscular strength/endurance training device.

Personal observations of battling rope use as a personal trainer demonstrate that cardio-respiratory fatigue does not seem to limit the participant's ability to complete multiple rounds of battling rope workout intervals but rather local upper body muscular fatigue prevents the participant from maintaining the initial form and cadence. This local upper body muscular fatigue is likely due to the rapid accumulation of muscle metabolites such as lactic acid and an alteration in tissue pH, during the intense work intervals which are known to reduce optimal muscle performance (Costill, Coyle, Fink, Lesmes & Witzmann, 1979).

Aerobic/anaerobic improvements have been seen with other HIIT protocols (Tabata et al., 1996) but the repetitive arm movements of battling ropes (weighing 20-75lbs) during HIIT will be stimulating adaptations in the upper body skeletal muscle and core (abdominal) muscle groups much like repetitive resistive arm curls and or sit-ups would be doing. Also grasping the battling rope over the repeated work intervals may result in improvements in grip strength following 4 weeks of HIIT. Traditional resistance training guidelines suggest that in order to improve muscular strength and endurance, individuals should participate in resistance exercise 2-4x a week. In order to improve strength of the muscle, less than 6 repetitions of an exercise should be performed and greater than 12 repetitions in order to improve muscular endurance, with a total of 2-6 sets (Baechle, Earle & Wathen, 2008). Understanding that battling ropes are a sub-maximal load for the upper body, if multiple sets and repetitions are being performed multiple times a week with HIIT, significant strength and endurance adaptations should be expected to occur. Given the lack of research data on battling ropes, standard strength/endurance measures for the muscle groups being used need to be determined to substantiate and understand the role that battling ropes may play in physical training and conditioning.

During HIIT, the high intensities that are achieved require substantial increases in ventilation, heart rate and oxygen consumption in order to meet and compensate for the metabolic demands of the exercise during the work period (Bahr, Gronnerod & Sejersted, 1992). With high intensity anaerobic exercise, oxygen consumption post exercise is elevated and depending on the program variables, can take up to 38 hours to return to pre-exercise values (LaForgia, Withers & Gore, 2006; Lyons et al., 2006; MacPherson et al., 2011; Schuenke, Mikat & McBride, 2002). This elevated oxygen consumption post exercise is known as the excess post-exercise oxygen consumption (EPOC) and occurs to assist metabolically in the replenishment of skeletal muscle ATP-creatine phosphate stores and removal of blood lactate as well as reduce the core temperature and oxygen consumption towards resting levels (Bangsbo et al. 1990; BØrsheim & Bahr 2003; Tomlin & Wenger, 2001). Measuring excess post-exercise oxygen consumption and blood lactate concentrations post-exercise will provide additional useful information on the anaerobic energy demands and immediate oxygen requirements associated with the recovery from HIIT exercise.

In conclusion, multiple HIIT protocols have demonstrated significant improvements in VO2 max. Battling ropes are an emerging exercise apparatus that is commonly used for HIIT protocols by strength and conditioning coaches in order to improve the aerobic/anaerobic energy systems and muscular endurance, with little or no published research to substantiate their effectiveness. Utilizing a common HIIT protocol with battling ropes similar to what is being used in the field and collecting quantitative data pre and post-training will provide insight into what aerobic/anaerobic and strength/endurance adaptations are occurring over 4 weeks of HIIT. This will ultimately provide scientific data to strength and conditioning professionals to substantiate their training regiments and to help optimize the use of battling ropes in their programs.

PURPOSE

The purpose of this experiment was to determine the physiological responses to a battling rope high intensity interval training protocol.

The specific objectives were to determine the effects of a 4 week battling rope HIIT protocol on:

1. Upper-body arm ergometer maximal oxygen consumption
2. Oxygen consumption pre, during and post battling rope HIIT workout
3. Blood lactate accumulation pre and post battling rope HIIT
4. Upper body muscular strength/endurance assessed by push-ups, sit-ups and grip strength

METHODS

Design

30 participants (15 male, 15 female) were recruited from the University of Windsor, Ontario, Canada, from the Department of Kinesiology. Participants filled out a Physical Activity Questionnaire Plus (PAR Q+, see Appendix A) in order to screen them for contraindications for high intensity exercise, in which all participants passed. Pre-intervention, the participants underwent baseline physiological and performance testing (height, weight, arm ergometer VO2 max, exercising heart rates, ratings of perceived exertion (RPE), ACSM push-up and handgrip strength tests as well as a YMCA sit-up test). The participants were tested during their first of 13 battling rope HIIT sessions, as well as on their 13th and final battling rope HIIT session for exercising VO2, exercising heart rates, ratings of perceived exertion values (RPE), cadence of each round, blood lactate concentrations pre and post exercise session (0 and 5 minutes) and 5 minutes of excess post exercise oxygen consumption (EPOC). Over approximately 4 weeks, 11 battling rope HIIT sessions (not including the pre and post intervention battling rope HIIT testing that occurs during the 1st and 13th sessions) took place for 10 rounds with a work to rest ratio of 30 seconds work: 60 seconds recovery. Thirty-six hours and a maximum of 5 days after the final battling rope HIIT session, the participants retested their battling rope performance measures (exercising VO2, heart rates, RPE, cadence, blood lactate and EPOC). Thirty-six hours to 5 days later, participants retested their baseline physiological and performance variables as well (arm ergometer VO2 max, exercising heart rates, RPE, ACSM push-up and handgrip tests as well as a YMCA sit-up test). The participant's

completed 13 total sessions over approximately 4 weeks. The final testing session completed the investigation.

Participants

Thirty recreationally active participants (15 male, 15 female) from the University of Windsor who had been exercising a minimum of 2 times a week for the past 6 months were recruited for this investigation (see Table 1). This population has been chosen because they are relatively healthy and familiar with the feelings of regular exercise (ie. muscle soreness, understand feeling of higher exercising heart rates) while demonstrating moderate fitness levels. Pre-intervention physiological and performance testing took place in the Multipurpose Room (Room 202) of the Human Kinetics Building at the University of Windsor. The participants were initially given a letter of consent (Appendix B) and were informed of the investigation details both verbally and in writing. Subsequently, the Physical Activity Readiness Questionnaire Plus (PAR-Q+, see Appendix A) was completed to determine whether participants were free of any known risks that would contraindicate their ability to partake in physical exercise. Participants underwent a participant health questionnaire (Appendix C) which provided a more in depth evaluation of their health and exercise status. Further, this information provided each participant’s date of birth and previous exercise experience. Participants were then asked to schedule their initial testing session following a 48 hour exercise and alcohol hiatus and were required to fast for 4 hours to prevent any interaction with the thermal effect of food (Burgomaster et al., 2008; Schuenke, Mikat & McBride, 2002). This same protocol was used before all testing sessions. All participants were asked to maintain their normal nutritional and exercise habits, within the time constraints and schedule of the intervention. This study was approved by the Research Ethics Board at the University of Windsor (REB#30455).

Sample Size

This investigation was designed to analyze any changes in an arm ergometer V02max, handgrip strength, push-up endurance, sit-up endurance and performance specific changes in VO2, EPOC and post exercise lactate concentrations. With an alpha level of 0.05, an effect size of 0.8 and a power of 0.6, the sample size necessary to detect significant changes was 12 participants of each sex. 15 of each sex were recruited without any dropout.

Endurance and Strength Tests

Baseline physical performance testing was administered to determine the effectiveness of the battling rope training protocol prior to the initiation of the training intervention and after the entire intervention was completed. The participants underwent standardized testing protocols for upper-body muscular endurance, core endurance and hand grip strength.

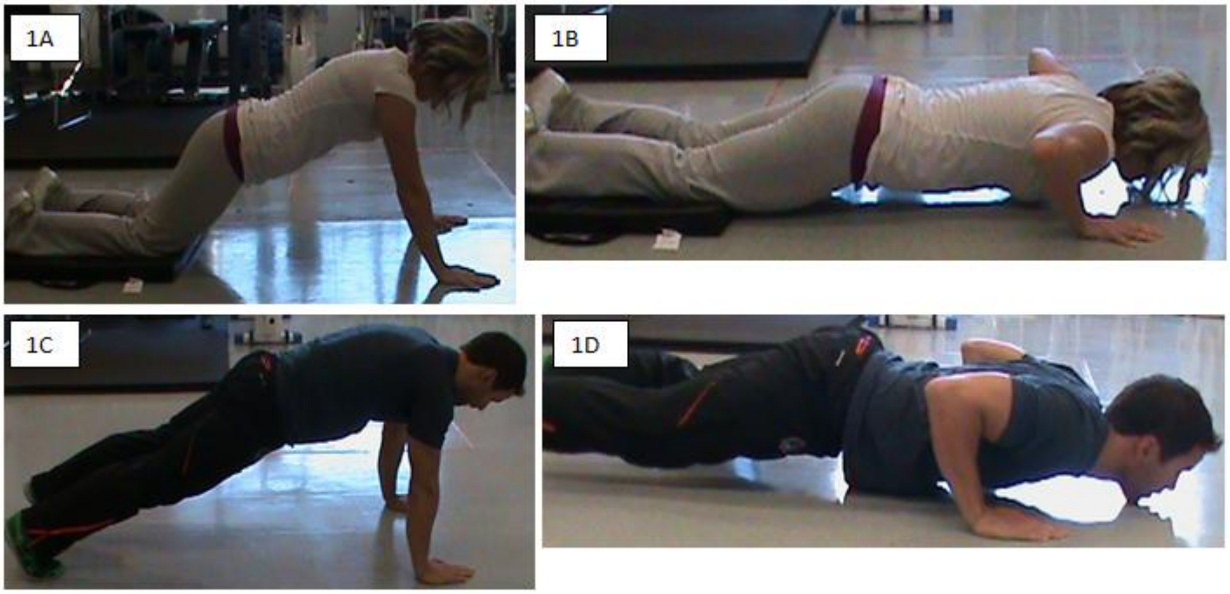


Figure 1A, 1B, 1C, and 1D: *Figure 1As the female starting (upward) position from the knees for the ASCM Push-up Test. Figure 1B the female downward position from the knees for the ACSM Push-up Test. Figure 1C the male starting (upward) position from the toes for the ACSM Push-up Test while Figure 1D the male downward position from the knees for the ACSM Push-up Test. Once the chin touches the floor, the participant returns to the starting position to complete one full repetition.*

To measure upper-body muscular endurance, the American College of Sports Medicine (ACSM) push-up test was utilized (Figure 1A-D). Subjects were told to place their hands on the floor, shoulder width apart. Females performed push-ups with support from their knees (Figure 1A and B) while males performed the push-up test while supported by their toes (Figure 1C and D). One successful push-up required the chin touching the ground and then returning to the starting position. Once they could no longer maintain proper form on two consecutive push-ups, the test was terminated. This test was designed to measure the maximal number of push-ups that a participant could do until volitional fatigue.

To measure core endurance, the YMCA Bent-Knee Sit-Up Test was used (Figure 2A-B). All participants laid on their back with their feet flat on a mat and hands behind their head, with their elbows forward. The investigator held the participant's feet in a stable position while the participant lifted their upper body off of the floor until their elbows touched their knees (i.e. a successful repetition). Subsequently, the participant lowered themselves to the floor until the upper portion of their back touched the mat. The investigator recorded how many repetitions were completed maximally in one minute.

Figure 2A and 2B: *Figure 2A was the starting (downward) position for the YMCA Bent-Knee Sit-Up Test. Figure 2B the upward position for the YMCA Bent-Knee Sit-Up Test. Once the elbows touch the knees, the participant returns to the starting position (the shoulder blades return to the mat) to complete one full repetition.*

To measure grip strength, a CardioGrip Hand Dynamometer (Model IBX-H 101) (Figure 3A) was used to record the force output of each hand in kilograms. Each hand was tested 3 times with the peak value of each being recorded (Figure 3B). The participant held his/her arm at 90 degrees when seated and the dynamometer was squeezed for 5 seconds (Aggarwal, 2012; Hoffman, 2006).

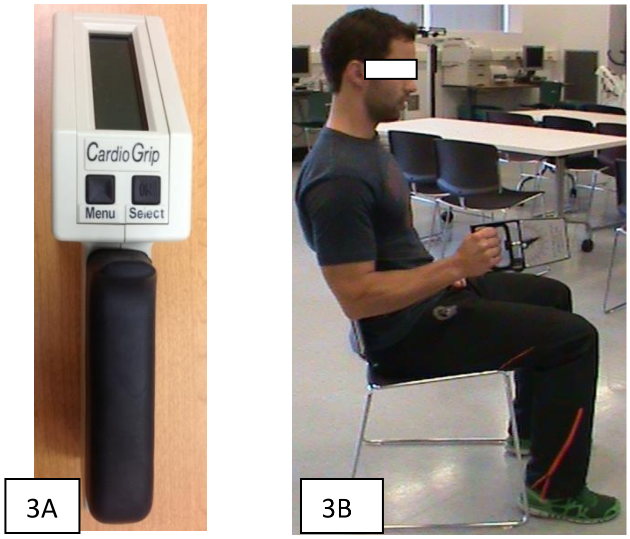


Figure 3A and 3B: *Figure 3A is the CardioGrip Hand Grip Dynamometer* (Model IBX-H 101). *Figure 3B s the hand grip strength test where the participant held the dynamometer at 90 degrees while seated and squeezed maximally for 5 seconds. The highest value of three trials was recorded.*

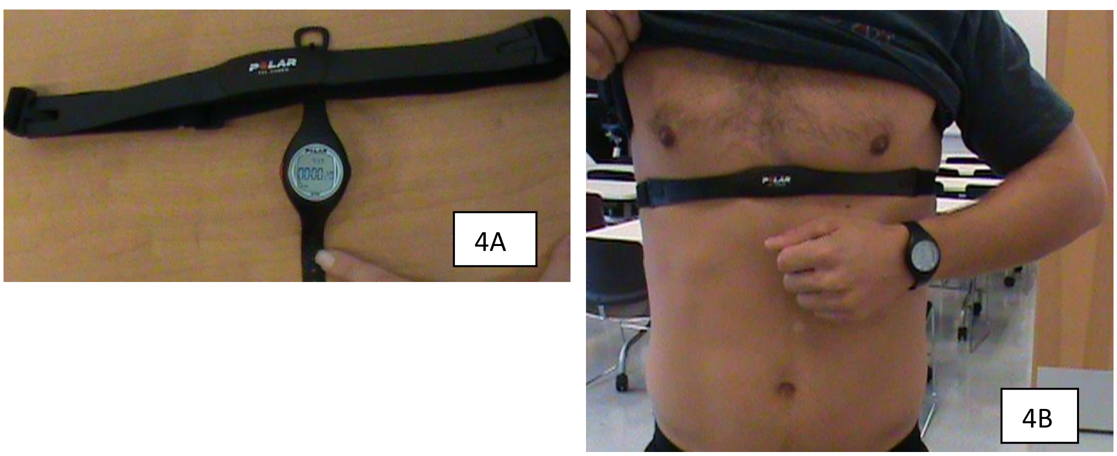


Figure 4A and 4B: *Figure 4A is the Polar HR Monitor (Model E40) watch and the corresponding chest strap. Figure 4B the proper placement of the Polar HR Monitor chest strap. The chest strap should rest below the nipples and be centered just below the sternum with the watch being worn on the wrist.*

Aerobic Capacity Testing

Prior to the aerobic capacity test, each participant was fitted with a Polar HR monitor (Model E40) (Figure 4A and 4B), which displayed their exercising heart rates at each stage of the VO2 max test.

Following the endurance and strength tests, a maximal oxygen consumption test (VO2 max test) for the upper body was conducted to determine the participant's ability to utilize oxygen. To determine the upper body VO2 max, a Monark Arm Ergometer (Model 881) (Figure 5A-B) designed for upper body aerobic testing was used. The protocol using the Monark Arm Ergometer was a progressive Astrand (1965) VO2 maximum protocol (see Appendix E).

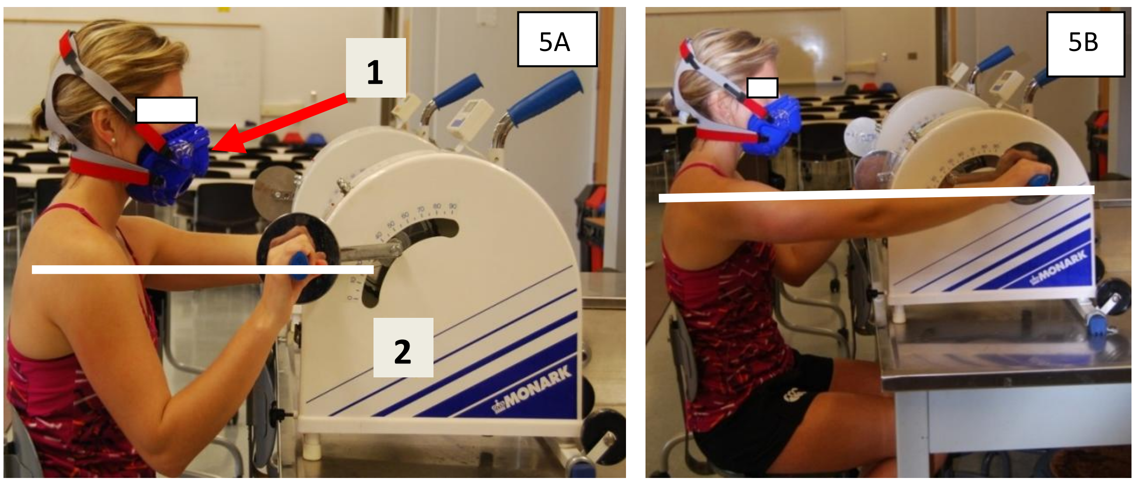


Figure 5A and 5B: *Figure 5A illustrates the starting position of the Astrand Arm Ergometer Protocol (Appendix E). The head of the humerus was set parallel to the axis of the arm ergometer pedal axis. Figure 5B illustrates the second half of a full rotation of the Arm Ergometer. The seat was set so that it allows adequate arm extension during the pedalling motion. "1" is the Hans Rudolph VO2 max mask with head straps for positioning and "2" is the Monark Arm Ergometer set to shoulder height.*

The participant was then fitted with a Hans Rudolph facemask (Model V2)(Figure 5A-B) which was attached to the VO2 testing apparatus (Cosmed Quark CPET: Metabolic Cart) for minute to minute gas collection and analysis.

The participant was seated and their seat/body position was set so that the head of the humerus was parallel to the axis of the arm ergometer pedals and seated at a distance that allowed adequate extension of the arm during pedalling (Figure 5A and B).

The subject was allowed to warm up for a 3 minutes to familiarize themselves with the arm ergometer motion. The participant began arm pedalling at 60 rpm; this was set using a digital visual display located on top the ergometer. The initial workload (resistance) was set at zero workload and then the workload was increased by 10 Watts every two minutes until the maximal workload of 100 Watts was reached (Appendix E). If the subject was still pedalling at 100 Watts, the workload was increased by instructing the participant to increase their revolutions per minute to 70rpm for 2 minutes and then finally set at 80 rpm for 2 minutes until volitional fatigue. Typically this test last approximately 11.67 minutes. During the arm ergometer workloads, gas collection and heart rate data were monitored via the Cosmed Quark CPET equipment, continuously until volitional fatigue. The Hans Rudolph facemask was sterilized in-between each participant in a sterilizing autoclave that is located in the PACR lab.

Prior to the initiation of the arm ergometer test, the subject was shown a Borg (1998) Ratings of Perceived Exertion (RPE) 10 point scale which represents the participant's perception of the degree of difficulty (Appendix F). During the actual test, the tester held up the chart at the end of each 2 minute stage and had the subject indicate the effort they perceive.

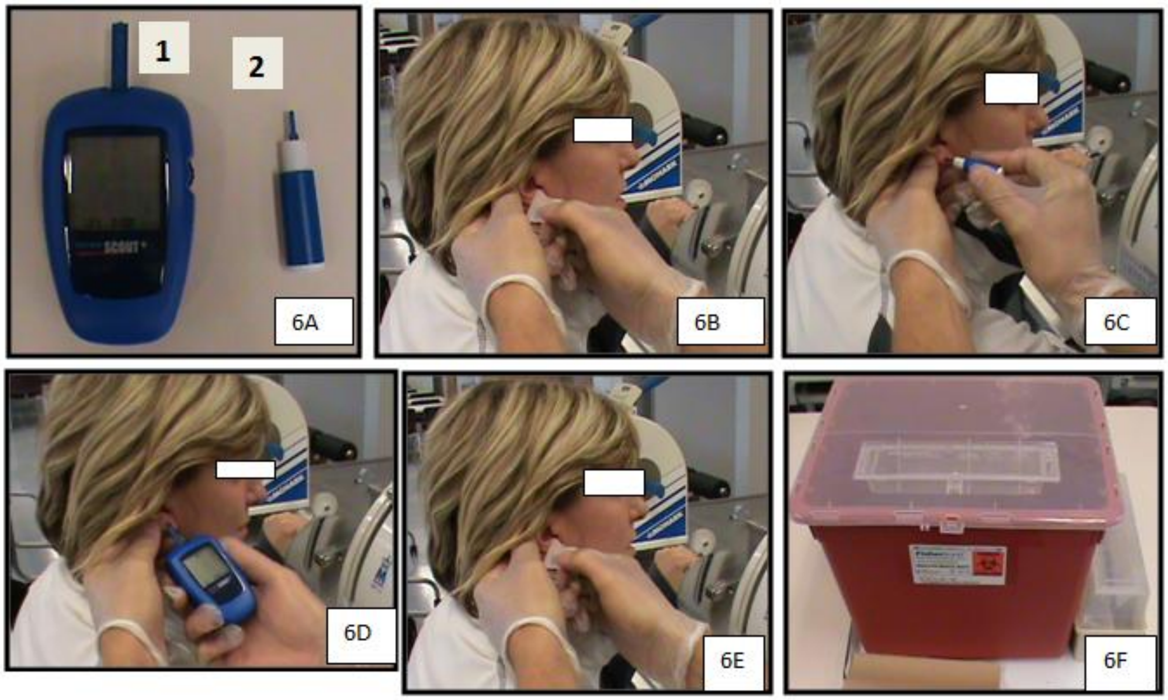


Figure 6A, 6B, 6C, 6D, 6E and 6F: *Figure 6A is the Lactate Scout Analyzer (1) and Medlance 1.8mm, 21G Autolancet (2) which were used for obtaining a single blood droplet and analyzing it for lactic acid concentrations. Figure 6B is the participant's ear being cleaned with an alcohol swab while the investigator wears protective gloves and safety glasses, prior to the obtaining of a blood droplet. Figure 6C is the use of the Medlance Autolancet which was held against the earlobe and pressed until it clicks and then disposed of into the sharps container. Figure 6D is the Lactate Scout testing strip being touched to the single droplet of blood on the earlobe. Once the droplet was touched the strip adequately and a reading was given by the Lactate Scout, the testing strip was disposed of into the sharps container. Figure 6E is the earlobe being cleaned with a different alcohol wipe post sample. The Medlance Autolancet lactate testing strip and alcohol wipe were all disposed of into the sharps container which is seen if Figure 6F. All areas used were disinfected post test, with the liquid disinfectant found in the lab.*

After a minimum of 36 hours and a maximum of 5 days following the first VO2 max testing, participants completed their first testing sessions of the HIIT protocol in the Multipurpose Research Room (Room 202) in the St Denis Centre. Upon arrival, the participant was seated for 5 minutes and then a baseline blood lactate concentration measurement was taken from the earlobe (Figure 6) (Moran, Prichard, Ansley &

Howatson, 2012). Before both HIIT testing and all training sessions, a standardized dynamic warm-up took place. This dynamic warm-up included 20 jumping jacks, 10 forward shoulder circles, 10 backwards shoulder circles, 10 wall stick ups, 10 alternating lunges and 10 push-ups. This ensured that the participant was properly prepared for the movements of the training session. Following the warm-up, a 3 minute rest break was taken prior to the HIIT VO2 testing to allow for adequate recovery from the warm-up.

Training Session Data Collection

The HIIT protocol spanned over 13 sessions (approximately 4 weeks). The participant was tested for exercising VO2, ratings of perceived exertion and HR responses during the 1st and 13th sessions, allowing for four full weeks of battling rope HIIT.

There are a number of exercises that can be done with battling ropes but two common motions for the battling ropes are: both arms moving together called the double whip (Figure 7A, 7B and 7C) and both arms moving alternatively (opposite to one another) in the vertical plane called the alternating whip (Figure 8A, 8B and 8C). For both exercises, the rope was bolted to the floor with steel anchors and the participant was coached on keeping their head up, core tight, knees slightly bent and to continue a comfortable breathing rate. Their knees and torso may not have remained completely stationary as they became fatigued but the investigator was constantly monitoring their technique and providing feedback. The participants were given the choice of wearing abrasion protection gloves or not wearing gloves based on their comfort level. Also, both the double and alternating whip exercises were demonstrated by the investigator prior to the start of the first testing session.

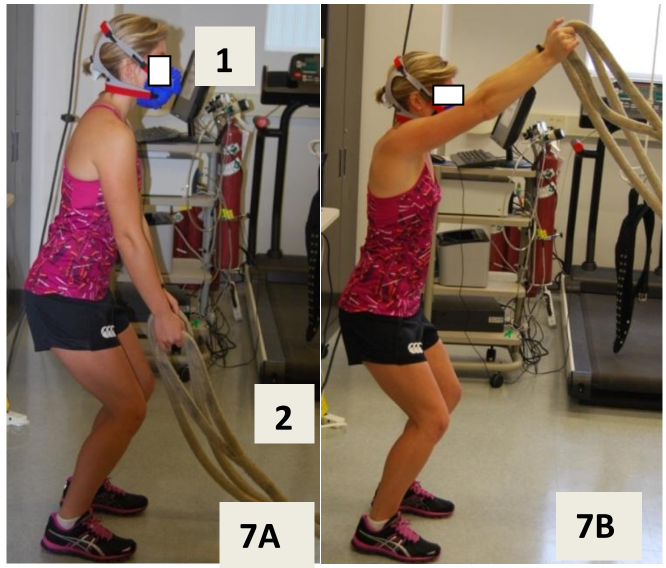
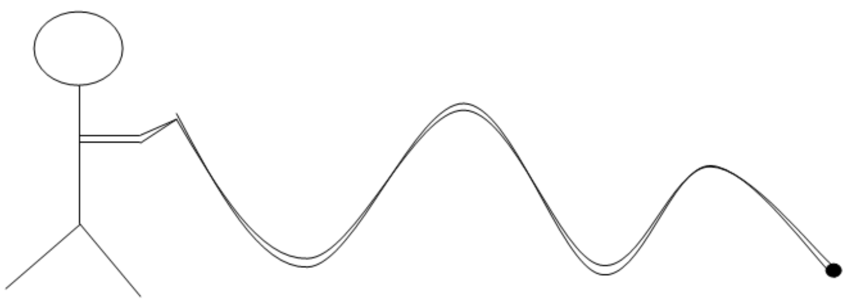


Figure 7A, 7B and 7C:
Figure 7A is the starting position of the double whip exercise (the down position) while wearing the Hans Rudolph VO2 mask and the Polar HR monitor. Figure 7B is the middle position (the up position) of the double whip exercise. Figure 7A also represents the finishing position of one complete cycle. "1" is the Hans Rudolph VO2 max mask. "2" is the 1.5 inch, 40 foot battling rope. 7C is a diagram demonstrating the "double whip" exercise rope movement.



7C

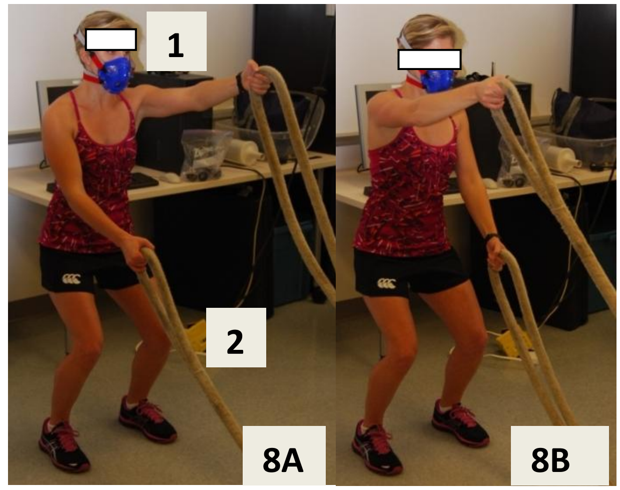
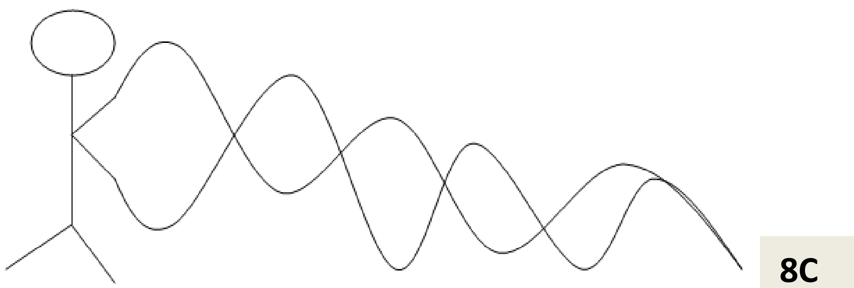


Figure 8A, 8B and 8C: *Figure 8A is the starting position of the alternating whip exercise while wearing the Hans Rudolph VO2 mask and HR monitor. Figure 8B is the alternate position of the alternating whip exercise. Figure 8A also represents the finishing position of the alternating whip exercise. “1” is the Hans Rudolph VO2 max mask. “2” is the 1.5 inch, 40 foot battling rope. Figure 8C is a diagram representing the second of the two main exercises with a battling rope. This is known as the “alternating whip”.*



Similar to the first VO2 max test, this battling rope testing session began with a participant being fitted with a Cosmed VO2 System Hans Rudolph VO2 mask and Polar HR monitor. Prior to the initiation of the HIIT protocol, the participants were informed about their work:rest interval ratio of 30:60 seconds. The participant stayed at this work:rest ratio for all 13 sessions (1 testing session on the first day with 1 more testing session after 11 regular HIIT sessions). This ratio of 1:2 was chosen because it has historically been investigated less than other more traditional HIIT protocols but has garnered more attention recently as it allows for a more practical application (i.e. easier to use with a group of 3 clients in a personal training setting, less recovery time with a paying client), while showing potential replicating the effects of other similar HIIT protocols (Freyssin et al., 2012; Gloeckl, Halle & Kenn, 2012; Jay et al., 2011; Ziemann et al., 2011).

Workout Round	Rope Exercise	
1	double whip	
2	alternating whip	
3	double whip	
4	alternating whip	**HIIT Protocol**:
5	double whip	30:60 (sec:sec)
6	alternating whip	
7	double whip	
8	alternating whip	
9	double whip	
10	alternating whip	

Figure 9: *The double whip and alternating whip exercises were interchanged each workout round in order to minimize specific muscular fatigue and reduce form breakdown from workout round to workout round.*

After the explanation of the HIIT protocol, the participant then began their “all out” exercising work interval with a double whip exercise with a 50 or 40 foot, 1.5 inch battling rope (Power Rope: North Carolina, USA), for 30 seconds (Figure 7A, 7B & 7C). Throughout all battling rope testing and training sessions, males used 50 foot, 1.5 inch, 25 pound battling ropes while females used 40 foot, 1.5 inch, 20 pound battling ropes. This was determined based on the difficulty displayed by female participants when using the 50 foot long rope for the proposed HIIT protocol during simulated testing sessions prior to the initiation of this investigation. After the 60 seconds of recovery, the participant was asked to complete a maximum “all out” effort of an alternating whip exercise for 30 seconds (Figure 8A, 8B & 8C)(Appendix G) and then took the same length of recovery for their second recovery break (during recovery the participant was seated between rounds). The double and alternating whip exercises were alternated each workout round (exercise being performed) in order to minimize specific muscular fatigue and reduce form breakdown from workout round to workout round (Figure 9).

Each exercise round was repeated 5 times for each rope exercise for a total of 10 workout rounds. During each work interval, the investigator manually recorded how many times the battling rope touched the ground for one full revolution (Double whip = rope hitting ground; alternating whip = right hand returned to elevated starting position). This allowed for the tracking of the frequency/cadence and any fatigue associated with decreased repetitions during each work interval.

A Gymboss Interval Timer (Figure 10) was used to administer the interval protocol with a “beep” to begin the work and rest periods. Also, after each round the investigator immediately asked the participant’s rating of perceived exertion (Borg RPE, see Appendix F). This indicated to the investigator how the participant felt his/her exertion level was on a scale of 0-10. At the end of the 10 workout rounds, the VO2 mask remained on for 5 minutes post HIIT testing for the collection of excess post-exercise oxygen consumption (EPOC) which was used to measure the immediate oxygen demands post HIIT protocol (Sedlock, 1994). Traditional EPOC measurements were not calculated due to the Cosmed VO2 System’s inability to adequately measure every breath during the five minutes. It was noticed by the investigator that multiple breaths were being discarded as “invalid breathes” during the post exercise period and are irretrievable, and thus reporting one summed number referring to all oxygen consumed during the 5 minute EPOC would have been invalid. Instead, the minimum heart rates and VO2 values that were achieved at the end of the 5 minute EPOC period are reported.

Figure 10: Gymboss Interval Timer that was preset to indicate the beginning and end of every work and rest period with a beep.

Also, while EPOC was being measured and the participant was seated and recovering, an earlobe prick for blood lactate analysis occurred immediately after the 10^{th} round and 5 minutes after the completion of the testing protocol (Figure 6). These blood lactate concentrations provided quantitative information as to the intensity of this type of training, during the pre and post training testing sessions.

The battling rope HIIT VO2 testing protocol described in the previous paragraph was repeated at the 13th and final training session (Appendix H) to assess the participant's metabolic and cardiopulmonary adaptations to the battling rope HIIT protocol. The initial Astrand VO2 max testing protocol occurred 2 times over the 4 weeks, once pre-intervention (before session 1) and once a minimum of 36 hours after the 13^{th} and final session. During all testing and training sessions, verbal coaching on form and encouragement was used with each participant.

Training Sessions

There were a total of 13 HIIT sessions (approximately 4 weeks) (Appendix H). An example of a practical schedule being completed is training on Mondays, Wednesdays and Fridays. As long as a minimum of 36 hours and a maximum of 5 days break between sessions were maintained throughout the training period, the participant remained enrolled in the study, regardless of their specific training schedule. Again, each session began with a dynamic warmup and finished with a static stretching routine. As previously mentioned, participants completed 10 workout rounds of a 30:60 HIIT ratio for the full 13 sessions.

As previously seen in Appendix G, each participant completed 30 seconds of "all out work" with a double whip exercise and then took their 60 second rest on a chair in a seated position. They then completed 30 seconds of "all out work" with the alternating whip exercise. They were also verbally encouraged to go as fast as they could during their work periods. Utilizing 10 rounds of this type of HIIT is common in the literature (Fountaine et al., 2011; Talanian et al., 2007).

Participant Confidentiality

Participant's personal information and testing results were stored confidentially. Digital data was secured on a password protected computer with the hard copies being locked in the lead investigator's office. All Cosmed VO2 data was stored on a password protected computer in the Undergraduate Laboratory. All personal data was stored under a unique participant identification number, rather than the participant's name. The lead investigator and the laboratory assistants were the only ones to have access to the personal data. Participants were notified that they were free to withdraw from the investigation at any point in time. No participants did so.

Statistics

Statistical analyses were performed using IBM SPSS 20. All data including descriptive statistics are presented as means and standard deviations (SD). Two separate multivariate analyses of variance (MANOVA) were done to analyze the performance (VO2 max, pushups and situps) and physiological data (Average peak VO2, average recovery VO2, peak heart rate, RPE and cadence during each round of the battling rope workout). Males and females had separate MANOVA's in order to analyze date specific to the sexes; totalling 4 MANOVA's. Direct comparison of the two sexes is not completed due to the different lengths of battling ropes that were used throughout the testing and training period. All MANOVA's required repeated measures on the factor of time (pre and post). After shared variance was investigated with the MANOVA, a discriminative analysis using univariate ANOVA's was conducted on specific performance (VO2 max, pushups and situps) and physiological data (Average peak VO2, average recovery VO2, peak heart rate, RPE and cadence during each round of the battling rope workout) to investigate and identify further relationships. For the analysis of lactate values, a 3 (resting, immediately after and 5 min post) x 2 (pre and post) repeated measures ANOVA was used, one for each sex. Paired t tests were used to compare resting, immediately post and 5 minutes post battling rope HIIT training for pre and post values for males and females. For the analysis of hand grip strength, a 2 (left and right hand) x 2 (pre and post) repeated measures ANOVA was used, one for each sex. Paired t-test's were used to determine where any unique differences with hand strength, lactate values, peak VO2 and peak HR for double and alternating whip as well as EPOC VO2 and

HR, existed for males and separately for females. Mean differences were considered statistically significant where $p < 0.05$.

RESULTS

Descriptive Statistics

Participant characteristics are outlined in Table 1.

Table 1. Participant characteristics

Sex	Age (years)	Weight (kg)	Height (m)
Males (n=15)	22.07 ± 1.75	81.63 ± 8.43	1.77 ± 0.08
Females (n=15)	21.73 ± 2.15	59.68 ± 5.79	1.66 ± 0.06

Values are means ± SD.

General Performance

Based on the MANOVA for performance variables (VO2 max, pushups and situps), males saw no significant interaction in general physical performance parameters $F(3, 12) = 2.7$, $p = .093$. Females saw a significant interaction in overall physical performance parameters $F(3, 12) = 44.371$, $p < .001$.

VO2 Maximum

Based on the univariate analyses, for males, there was no significant improvement in VO2 maximum over the 4 week battling rope HIIT period $F(1, 14) = .628$, $p = .441$. Females, however did demonstrate a significant improvement in VO2 max $F(1, 14) = 6.001$, $p < .05$ (Table 2) following the 4 week battling rope HIIT.

Table 2. Summary of pre and post battling rope HIIT performance measures for male and female participants

Sex		VO2max (ml·kg·min)	Pushups (# to fatigue)	Situps (# in 1 min)	Handgrip (kg)	
					Right	Left
Male (n=15)	Pre	34.9 ± 6.5	30.0 ± 11.8	45.6 ± 10.2	46.9 ± 6.2	46.5 ± 7.4
	Post	35.7 ± 7.0	33.3 ± 11.3*	47.5 ± 11.3	47.5 ± 7.2	44.8 ± 7.7**
Female (n=15)	Pre	31.1 ± 4.0	29.1 ± 9.4	34.3 ± 8.5	29.4 ± 4.2	27.0 ± 4.8
	Post	33.5 ± 3.2ǂ	39.7 ± 10.1ǂǂǂ	37.8 ± 9.5ǂǂ	29.7 ± 4.6	26.9 ± 4.9

Values are means ± SD.
Pre vs post for males only *p<0.05, **p<0.01.
Pre vs post for females only ǂp<0.05, ǂǂp<0.01, ǂǂǂp<0.001

Pushups

Based on the univariate analyses, for males, there was a significant improvement in pushups over the 4 week battling rope HIIT period $F(1, 14) = 6.119$, $p<.05$. Females demonstrated a significant improvement $F(1, 14) = 109.442$, $p<.001$ as well (Table 2) following the 4 week battling rope HIIT.

Situps

Based on the univariate analyses, for males, there was no significant improvement in situps over the 4 week battling rope HIIT period $F(1, 14) = 1.672$, $p= 2.17$. Females demonstrated a significant improvement in situp performance $F(1, 14) = 12.149$, $p<.01$ (Table 2).

Handgrip Strength

For males, there was a main effect between each hand and the pre and post measurements of handgrip strength $F(1, 14) = 16.075$, $p<.01$. Utilizing individual paired t tests, it was determined that the left hand significantly decreased in strength over the 4 week training period $t(14)= 3.182$, $p<.01$ (Table 2).

For females, there was no main effect between each hand and the pre and post measurements on handgrip strength $F(1,14)= .434$, $p=.521$ (Table 2).

Battling Rope Specific Physiological Performance

During the battling rope HIIT investigation, males used a 1.5 inch, 50 foot, 25 pound rope while females used a 1.5 inch, 40 foot, 20 pound rope. For the MANOVA of round by round battling rope specific physiological performance (average peak VO2, average recovery VO2, peak HR, RPE and cadence during each round of the battling rope workout), the results showed that for males there was a significant interaction over time $F(5, 10) = 7.893$, $p<.01$.

Females saw a significant interaction over time in round by round battling rope specific physiological performance (average peak VO2, average recovery VO2, peak HR, RPE and cadence during each round of the battling rope workout) $F(5, 10) = 4.204$, $p<.05$.

Round by Round Average Peak and Average Recovery VO2

Based on the univariate analyses, for males, there was no significant difference in average peak VO2 attained during the battling rope HIIT over the 4 week training period when all 10 rounds were averaged together, $F(1, 14) = 1.742$, $p= .208$ (Figure 11).

However, females demonstrated a significant increase in average peak VO2 attained during battling rope HIIT over the same time period, $F(1, 14) = 8.507$, $p<.05$ (Figure 12).

Based on the univariate analyses, for males, there was no significant difference in average recovery VO2 attained during the 60 seconds of rest, during the battling rope HIIT over the 4 week training period when all 10 rounds were averaged together, $F(1, 14) = .040$, $p= .845$ (Figure 11). However, females demonstrated a significant increase in average recovery VO2 attained during the 60 seconds of rest, during the battling rope HIIT over the same time period, $F(1, 14) = 5.057$, $p<.05$ (Figure 12).

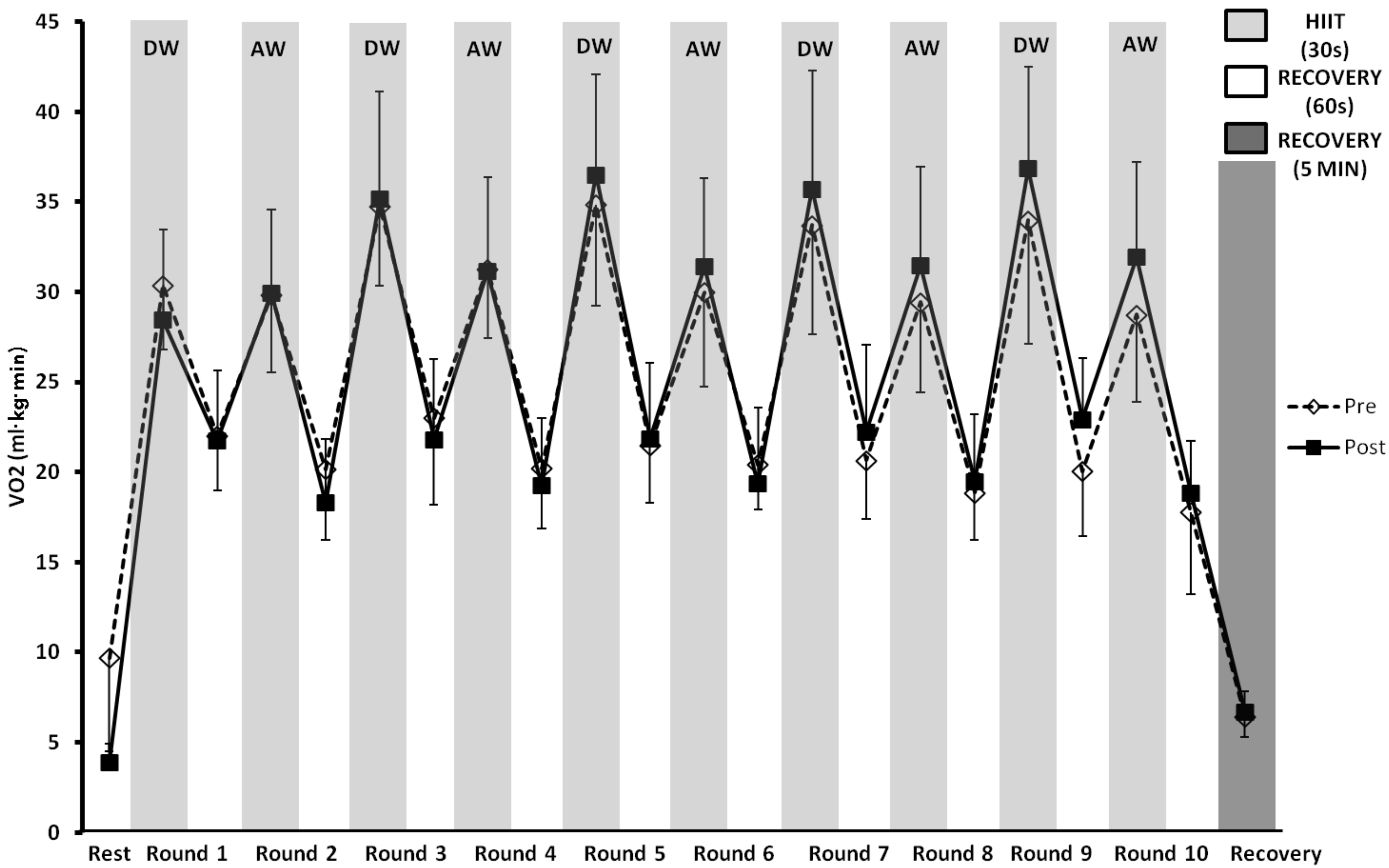


Figure 11. Males (n=15) average peak VO2 (ml·kg·min) at rest, during each of the 30 second exercise rounds of either double whip (DW) or alternating whip (AW) battling rope HIIT (light grey background), recovery VO2 during their 60 seconds of rest and the recovery VO2 (dark grey background) that was reached at the end of the 5 minutes of post workout recovery, both pre and post 4 weeks of HIIT.

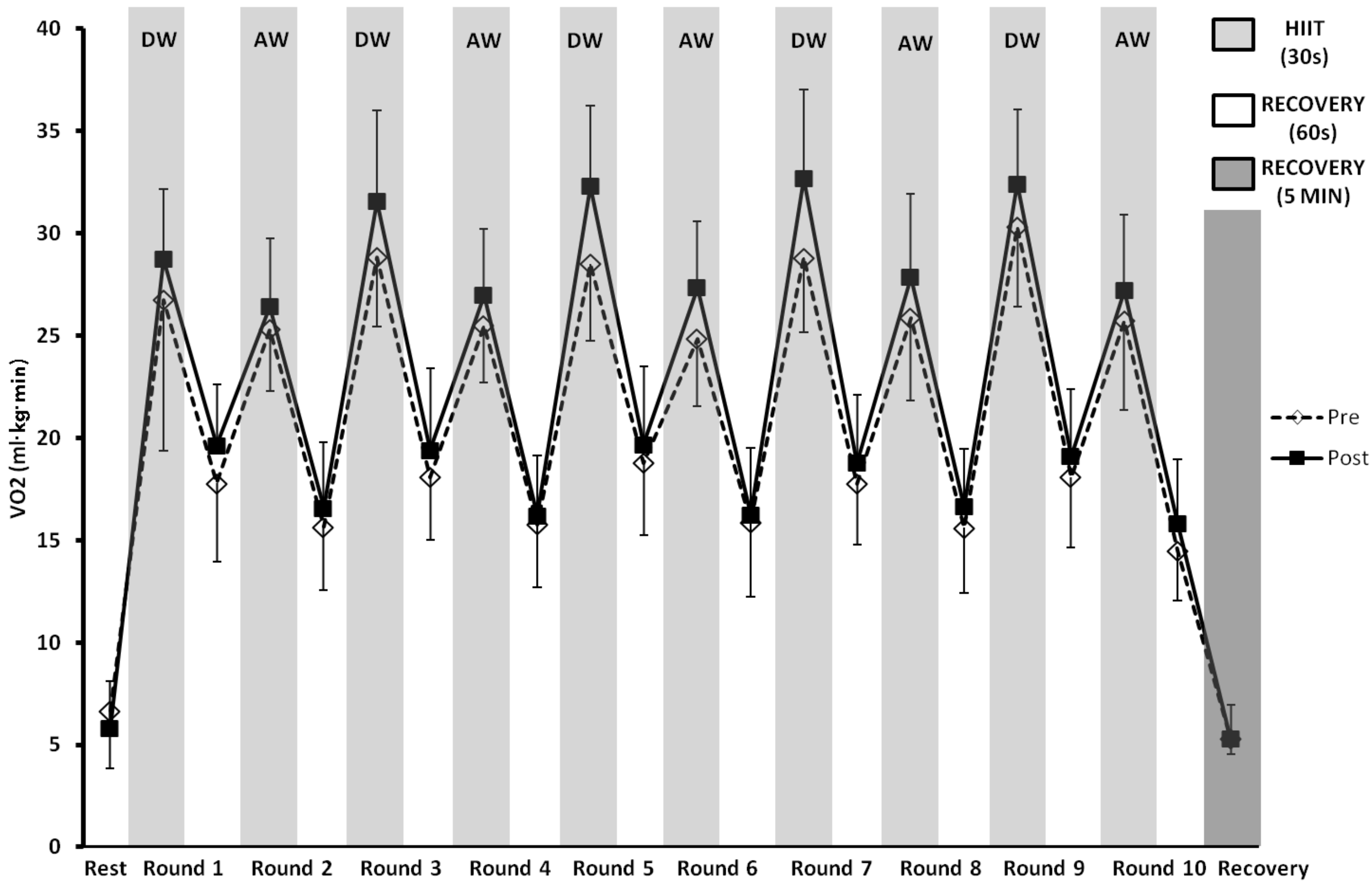


Figure 12. Females (n=15) average peak VO2 (ml·kg·min) at rest, during each of the 30 second exercise rounds of either double whip (DW) or alternating whip (AW) battling rope HIIT (light grey background), recovery VO2 during their 60 seconds of rest and the recovery VO2 (dark grey background) that was reached at the end of the 5 minutes of post workout recovery, both pre and post 4 weeks of HIIT.

We also calculated if there were any differences in peak VO2 averaged for all double whip rounds versus the alternating whip rounds for males, using paired t tests. As seen in Table 3, double whip peak VO2 was significantly higher for both pre ($t(74) = 7.974$, $p<.001$) and post ($t(74) = 7.284$, $p<.001$) data, compared to peak VO2 for alternating whip (Table 3).

Similarly, for females there was a significant difference in peak VO2 averaged for all double whip rounds for both pre ($t(74) = 6.573$, $p<.001$) and post ($t(74) = 13.154$, $p<.001$) data compared to the peak VO2 values averaged for all alternating whip rounds (Table 3).

Table 3. Double whip vs. alternating whip average (avg) peak VO2 and average peak heart rate (HR) data pre and post 4 weeks of battling rope HIIT

Sex		Avg Peak VO2 Double Whip (ml·kg·min)	Avg Peak VO2 Alternating Whip (ml·kg·min)	Avg Peak HR Double Whip (bpm)	Avg Peak HR Alternating Whip (bpm)
Males	Pre	33.53±5.53	29.85±4.62***	170.77±15.40	173.58±10.76*
(n=15)	Post	34.54±6.41	31.187±5.02***	167.25±13.34	170.14±11.13***
Females	Pre	28.74±4.68	25.46±3.49‡‡‡	172.38±13.90	175.09±12.68‡
(n=15)	Post	31.54±4.13	27.16±3.46‡‡‡	170.69±12.91	173.76±10.30‡‡

Values are means ± SD. beats per minute – (bpm)
Double whip vs Alternating Whip for males only *$p<0.05$, ***$p<0.001$.
Double whip vs Alternating Whip for females only $^{\ddagger}p<0.05$, $^{\ddagger\ddagger}p<0.01$, $^{\ddagger\ddagger\ddagger}p<0.001$

Round by Round Peak HR

Based on the univariate analyses, , there were no significant changes in the peak heart rate reached during final battling rope HIIT testing when all 10 rounds were averaged together, following 4 weeks of battling rope HIIT for males $F(1, 14) = 2.559$, $p=.132$ (Figure 13) and females $F(1, 14) = .319$, $p=.581$ (Figure 14).

To investigate for differences in peak heart rates when averaged for all double whip rounds versus the alternating whip rounds, paired t tests were used. There was a significant difference in males for both pre ($t(74) = -2.596$, $p<.05$) and post ($t(74) = -4.584$, $p<.001$) data where the alternating whip exercise displayed higher average peak HR values compared to the double whip exercise (Table 3).

For females, in both pre ($t(74) = -2.160$, $p<.05$) and post ($t(74) = -3.609$, $p<.01$) testing, heart data for the alternating whip exercise displayed higher peak heart rate values than the double whip exercise rounds (Table 3).

5 Minute Excess Post-Exercise Oxygen Consumption (EPOC) VO2 and HR

When comparing the pre and post 5 minute post HIIT EPOC VO2 values, there was no significant difference for males $t(14)= -0.898$, $p= 0.384$ (Figure 11). When doing the same for the 5 minute post HIIT EPOC HR, there was no significant difference for males $t(13)= 1.669$, $p=0.119$ (Figure 13).

When comparing the pre and post 5 minute post HIIT EPOC VO2 values, there was no significant difference for females $t(14)= -0.040$, $p=0.969$ (Figure 12). When comparing the pre and post 5 minutes post HIIT EPOC HR, there was no significant difference for females $t(11)=0.260$, $p=0.800$ (Figure 14).

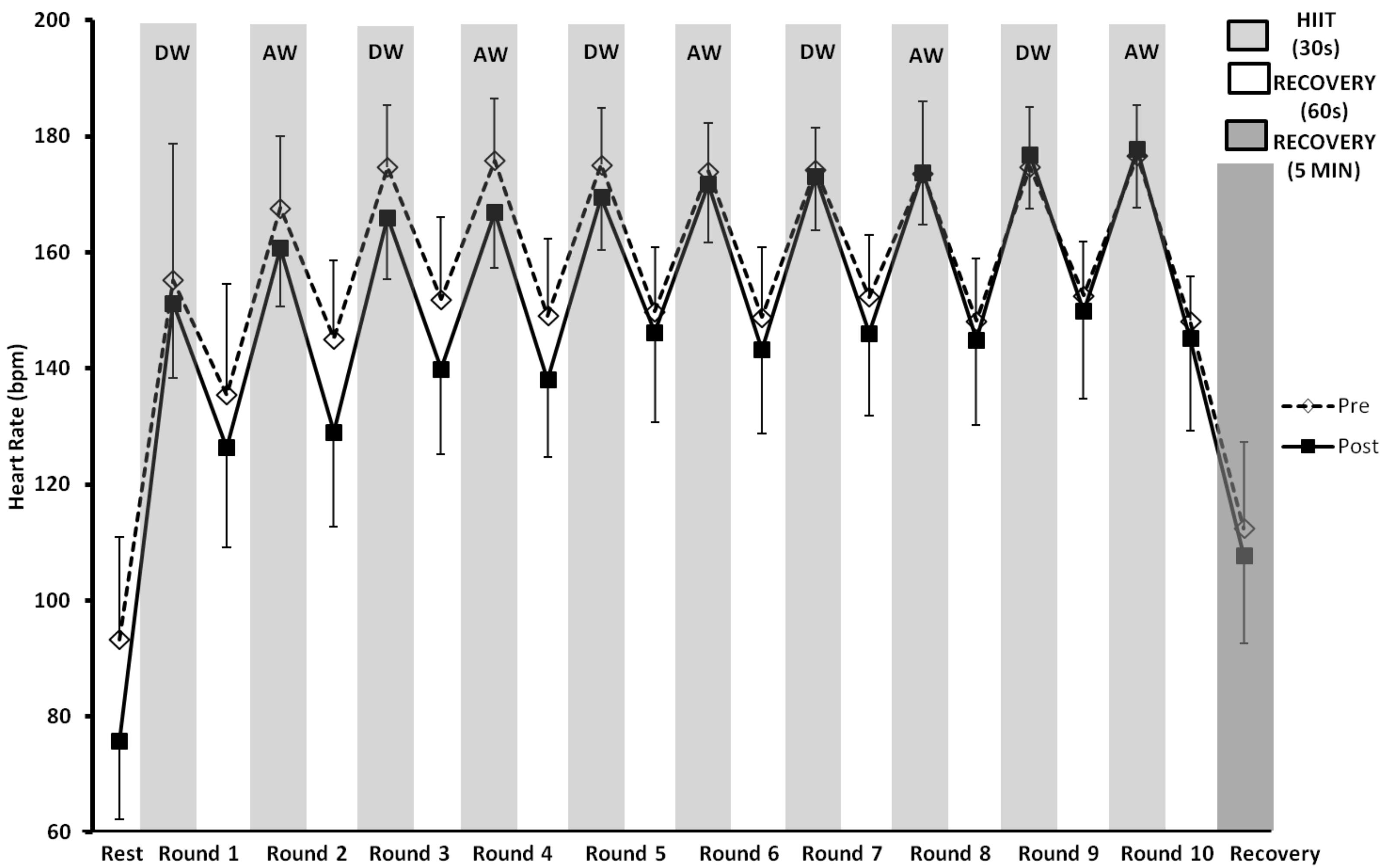


Figure 13. Males (n=15) average peak HR (bpm) at rest, during each of the 30 second exercise rounds of either double whip (DW) or alternating whip (AW) battling rope HIIT (light grey background), recovery HR during their 60 seconds of rest and the recovery HR (dark grey background) that was reached at the end of the 5 minutes of post workout recovery, both pre and post 4 weeks of HIIT.

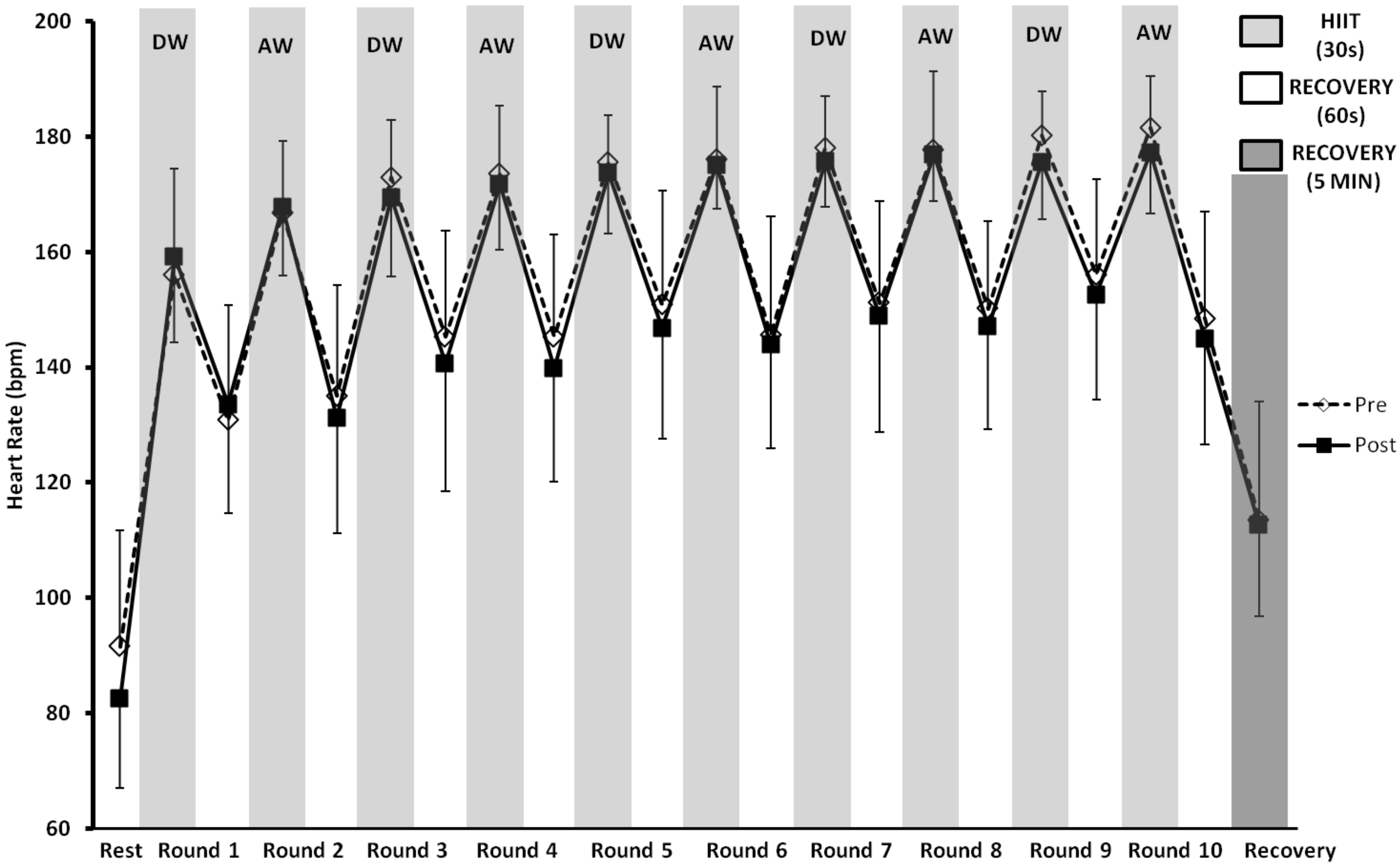


Figure 14. Females (n=15) average peak HR (bpm) at rest, during each of the 30 second exercise rounds of either double whip (DW) or alternating whip (AW) battling rope HIIT (light grey background), recovery HR during their 60 seconds of rest and the recovery HR (dark grey background) that was reached at the end of the 5 minutes of post workout recovery, both pre and post 4 weeks of HIIT.

Blood Lactate Concentrations

For males, the resting blood lactate concentrations rose significantly from HIIT compared to the immediately after the battling rope HIIT workout values for both pre 4 weeks of training (t(14)=-13.158, p<.001) and post 4 weeks of training (t(14)=-8.324, p<.001). Also, the 5 minute recovery blood lactate values were significantly higher than the resting values, both pre (t(14)=-16.483, p<.001) and post (t(14)=-10.597, p<.001) 4 weeks of training. Blood lactate concentrations were also assessed 5 minutes after the initial post workout blood lactate (immediately after workout) to allow for diffusion of intramuscular lactate into the blood stream and were found to be significantly higher but only post 4 weeks of battling rope HIIT (t(14)=-2.279, p<.05) (Table 4).

For females, resting blood lactate concentrations rose significantly immediately after the pre battling rope HIIT assessment (t(14)=-11.168, p<.001) and post 4 weeks of training (t(14)=-8.607, p<.001). Also, the 5 minute recovery blood lactate values are significantly higher than the resting values, both pre (t(14)=-16.433, p<.001) and post (t(14)=-10.970, p<.001) 4 weeks of training. Blood lactate concentrations were also assessed 5 minutes after the initial post workout blood lactate and were found to be significantly higher for both pre (t(14)=-2.247, p<.05) and post (t(14)=-2.293, p<.05) 4 weeks of training (Table 4).

Table 4. Summary of pre and post battling rope HIIT blood lactate values for male and female participants

Sex		Resting Blood Lactate (mmol/L)	Immediately After Workout (mmol/L)	5 Minutes After Workout (mmol/L)
Male	Pre	1.69 ± .62	10.06 ± 2.40***	11.06 ± 2.09***
(n=15)	Post	1.86 ± .31	9.17 ± 3.51***	10.29 ± 3.19***ǂ
Female	Pre	1.39 ± .41	8.17 ± 2.43***	9.36 ± 1.94***ǂ
(n=15)	Post	1.59 ± .43	8.28 ± 3.07 ***	9.35 ± 2.74***ǂ

Values are means ± SD.
Rest vs immediately after/5min post for males and females ***$p<0.001$.
Immediately after vs 5min post for males and females ǂ$p<0.05$.

For males, there was no significant interaction between the time blood lactate concentration was taken (resting, immediately after and 5 minutes after) and pre and post intervention values $F(2, 28)= 1.286$, $p= .292$. Also, there was no significant difference between pre and post values of lactate $F(1,14)= 1.102$, $p= .312$ (Table 4). Therefore the 4 week training protocol had no effect on the rises in blood lactate.

For females, there was no significant interaction between the time the blood lactate concentration was taken (resting, immediately after HIIT session and 5 minutes post HIIT) with pre and post intervention values $F(2,28)= .044$, $p= .957$. Also, there was no significant difference between pre and post values of lactate $F(1, 14)= .041$, $p= .843$ (Table 4). Therefore the 4 week training protocol had no effect on blood lactate concentrations.

Round by Round RPE

Based on the univariate analyses, for males, there was a significant decrease in RPE over the training period $F (1, 14) = 11.457$, $p<.05$ (Figure 15). Females demonstrated no significant changes in RPE over the training period $F (1, 14) = .001$, $p=.970$ (Figure 16).

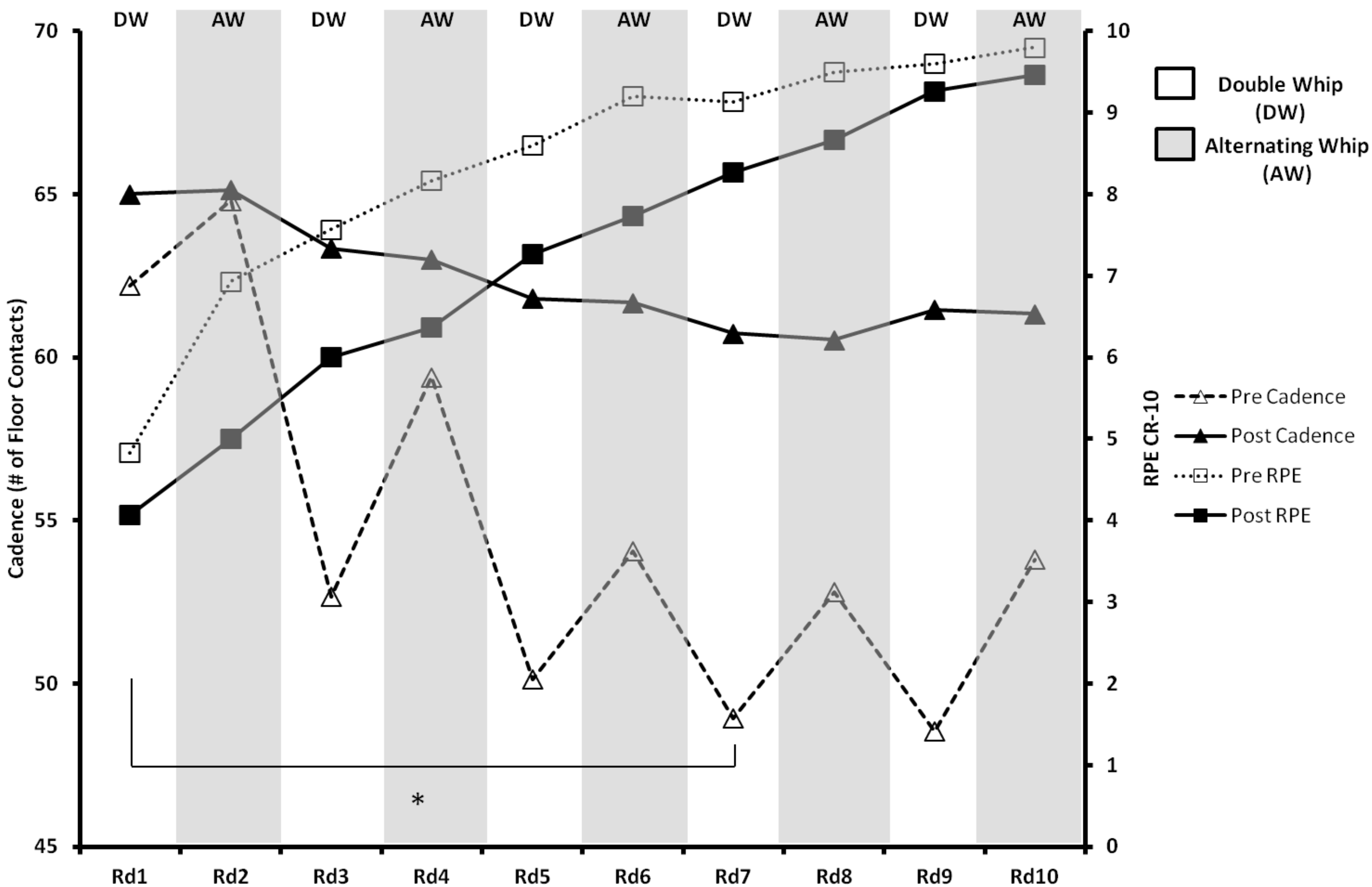


Figure 15. Cadence (# of floor contacts) during each of the 30 second rounds of either double whip (DW) or alternating whip (AW-light grey) battling rope HIIT with Ratings of Perceived Exertion (RPE CR10, 0-10) for males (n=15), for each round, pre and post 4 weeks of HIIT.

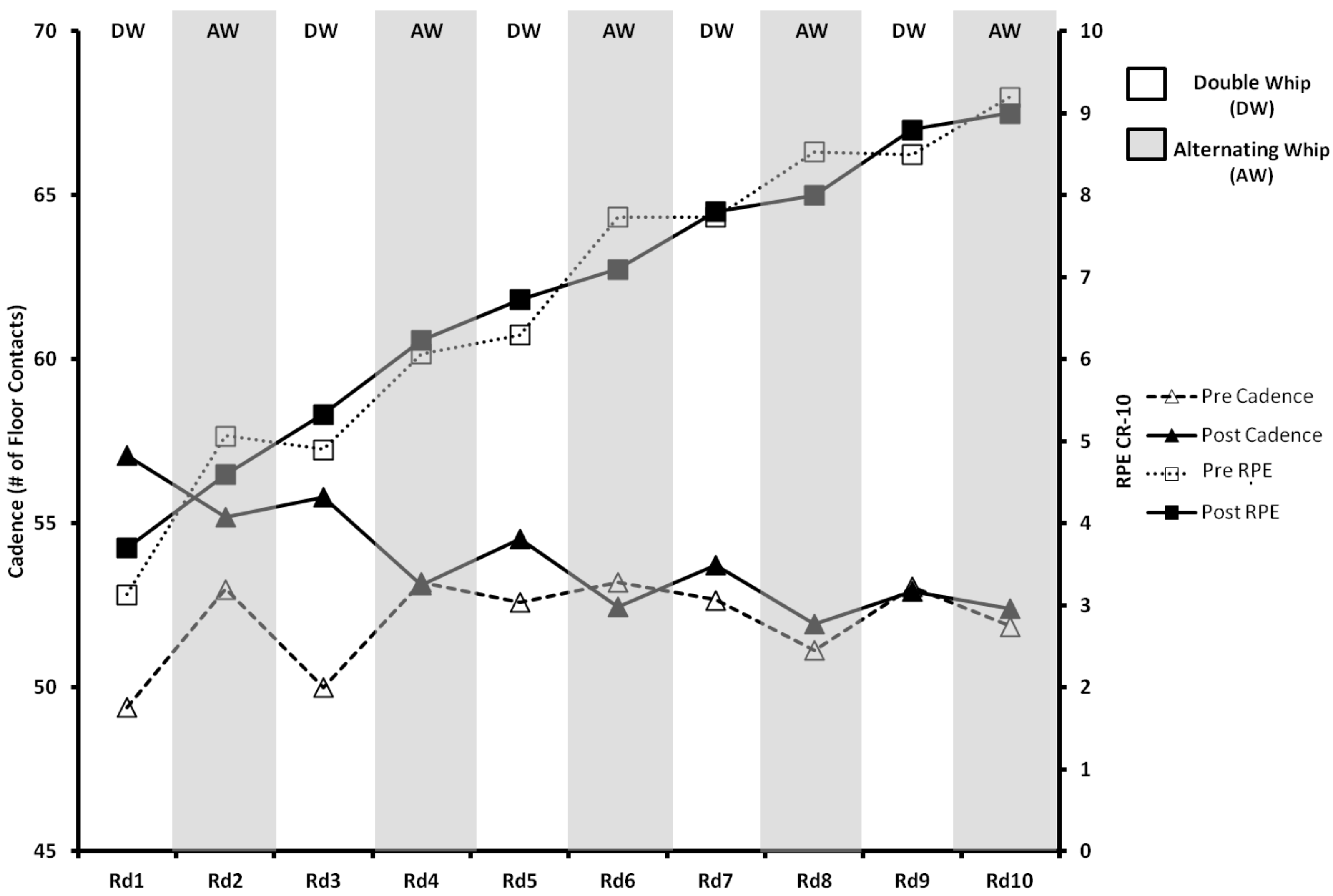


Figure 16. Cadence (# of floor contacts) during each of the 30 second rounds of either double whip (DW) or alternating whip (AW-light grey) battling rope HIIT with Ratings of Perceived Exertion (RPE, CR10 0-10) for females (n=15), for each round, pre and post 4 weeks of HIIT.

Round by Round Cadence

During each work interval, the investigator manually recorded how many times the battling rope touched the ground for one full revolution (Double whip = rope hitting ground; alternating whip = right hand returned to elevated starting position). This allowed for the tracking of the frequency/cadence and any fatigue associated with a decreased cadence during each work interval. Based on the univariate analyses, for males, there was a significant increase in rope cadence over the training period $F(1, 14) = 13.481$, $p<.05$. Post hoc tests using the Bonferroni correction revealed that round 1 and round 7 (both of the double whip exercise) were significantly different (62.2±14.24 floor contacts vs 48.93±8.85 floor contacts) ($p<.05$) (Figure 15). Females demonstrated no significant changes $F(1, 14) = .691$, $p=.420$ (Table 5) (Figure 16) in rope cadence for either the double whip or alternating whip.

DISCUSSION

High intensity interval training (HIIT) has been shown to improve aerobic and anaerobic conditioning as well as muscular endurance in both recreationally active males and females, commonly with 4-8 weeks of training using traditional exercise equipment such as treadmills and cycle ergometers (Astorino et al., 2012; Driller et al., 2009; Gibala et al., 2006; Hood et al., 2011; Laursen & Jenkins, 2002; MacDougall et al., 1998, Rodas et al., 2000; Tabata et al., 1996). Recently in the strength and conditioning field, unique training apparatuses such as kettlebells, which require whole body power and control, have been used to improve maximal aerobic capacity (VO2 max) with HIIT.

Falatic (2011) trained 17 female varsity soccer players over 4 weeks using a work:rest ratio of 15seconds:15seconds while performing repetitive kettlebell snatches and reported a significant 6% improvement in VO2 max. In regards to upper body dominant HIIT, the use of wheelchairs and arm ergometers with work to rest ratios of 1 to 4 minutes, have also demonstrated significant increases in VO2 max ranging from 13-36% over 6 weeks of training (Le Foll-de Moro et al., 2005; Maire et al., 2004).

Strength and conditioning professionals are also utilizing large diameter ropes (1-2 inches) weighing approximately 20-75 pounds called battling ropes to potentially improve clients VO2 max's while using battling rope HIIT protocols. However, to our knowledge, there is no published research examining VO2 max changes and muscular endurance and/or strength changes with battling rope HIIT. In the only published battling rope research, Fountaine, Adolph and Sheckler (2011) examined the acute responses to a single battling rope workout consisting of 10 rounds of 15 seconds of a maximal double whip exercise with a 1.5 inch, 50 foot, 36 pound rope, followed by 45 seconds of rest and reported exercising heart rates were 83% of calculated maximum heart rate. The limited amount of HIIT research with battling ropes provides an opportunity for researchers to identify the adaptations and influences that battling rope HIIT may have, in recreationally active populations.

In the current study, 4 weeks of HIIT, 3x/week with battling ropes showed a significant improvement of 7.8% in arm ergometer VO2 max for females when training with the 40 foot battling rope. In our trials prior to data collection, it was determined that females were unable to successfully complete the 10 rounds of battling rope HIIT using the 1.5 inch, 25 lb, 50 foot rope. To accommodate the female participants, we determined that the 1.5 inch rope if shortened to 40 feet, now weighing only 20 lbs, could be effectively used by females for the 10 rounds of battling rope HIIT. Our improvements in VO2 max are similar to previous HIIT research for females, which have shown increases ranging from 5% to 13.5% following 2 to 8 weeks of training using cycle, rowing and arm ergometers to perform the HIIT (Astorino, Allen, Roberson, Jurancich, Lewis, McCarthy and Trost, 2012; Burke, Thayer and Belcamino, 1994; Driller et al., 2009; Maire et al., 2004).

In contrast to the VO2 improvements for females in this study, our male participants training with the 50 foot rope, demonstrated no significant increases in arm ergometer VO2 max following the 4 weeks of battling rope HIIT. This is in contrast to 4 weeks of leg cycling HIIT (Bayati et al., 2011) or 4 weeks of rowing HIIT (Driller et al., 2009) where increases in VO2 max of 7 to 16% respectively have been reported when training recreationally active, young male participants.

Previous HIIT literature has typically reported that male and female participants demonstrate similar improvements in VO2 max values, peak and mean power outputs and changes in the respiratory exchange ratios when training the with a cycle ergometer (Astorino et al., 2011; Eddy, Sparks & Adelizi, 1977). For example, Astorino et al (2011) demonstrated that when males and females underwent the same cycle ergometer Wingate HIIT program over 2-3 weeks which consisted of 4-6, 30 second sprints with 4 minutes of recovery, VO2 max values increased with similar values of 5.9% and 6.8% for males and females respectively.

During HIIT, investigators often include a component of progressive overload with their training resistances on a weekly or bi-weekly basis over 4-15 weeks to enhance training gains (Bayati et al., 2011; Burgomaster et al., 2008; Eddy, Sparks & Adelizi, 1977: Rodas et al., 2000; Tremblay et al., 1994). We did not include progressive overload as we expected the battling rope double and alternating whip cadences to slowly increase with training and those increases would serve as a progressive overload to enhance VO2 gains through the 4 weeks of upper body battling ropes HIIT. Our data indicates a significant increase in the round by round cadence for males using the 50 ft rope over the 4 weeks of HIIT (see Figure 15). However, while cadence increased for both the double and alternating whip, male ratings of perceived exertion decreased with training, suggesting a need for a more traditional overload protocol using battling ropes for males, in order to evoke a VO2 change.

In contrast, the female participants demonstrated an improvement in arm ergometry VO2 max but did not significantly increase their cadence and ratings of perceived exertion when compared to pre HIIT values. This indicates that the 40 ft rope used by the females was an adequate stimulus to promote VO2 changes in their generally smaller upper body musculature over 4 weeks. Interestingly, Astorino et al (2012) suggested individuals with a high Wingate fatigue index (determined prior to training) demonstrate higher VO2 max improvements with HIIT. If we had assessed fatigue index using arm ergometry Wingates prior to training, we may have seen higher initial female fatigue indexes, especially given their smaller upper body musculature, which may have contribute to the significant VO2 changes.

Given that our female participants had a lower initial VO2 max and a lower upper body endurance as indicated by fewer pushups (Table 2), females may have possessed a greater adaptive VO2 and endurance potential than their male counterparts. Previous resistance and HIIT protocols suggest that incorporating a progressive training overload can improve training adaptations and in the current study increasing rope size/weight, rope length, reduced rest interval and/or increased work intervals for both female and male participants may have further enhanced or initiated VO2 gains during 4 weeks of battling rope HIIT and warrants further investigation.

The current study was the first to measure VO2 data during both the work and recovery intervals of battling rope HIIT, prior to and after 4 weeks of HIIT. Following 4 weeks of battling rope HIIT, females significantly increased their average peak VO2 during the work intervals by 8.4% and average recovery VO2 by 6.1%, where the average VO2 values were determined from all 10 battling rope work and recovery intervals (Figure 12). The Astrand arm ergometer test showed a 7.8% increase in female VO2 max following 4 weeks of HIIT. Comparing average peak HIIT VO2 and arm ergometry VO2 maximum data, participants were exercising at approximately 90% of their arm ergometer VO2 max. The data also indicates that when training with battling ropes, VO2 changes can be effectively assessed using standard arm ergometry tests or during the actual battling rope HIIT, which has not been demonstrated in the research up to this point. In the case of male participants, neither average peak VO2 nor average recovery VO2 showed any significant change with our 4 weeks of battling rope HIIT (Figure 11).

The pre and post cadence and RPE values for females (Figure 16) during each round showed no significant changes, which suggests that the 40 foot, 1.5 inch battling rope was an adequate training tool to increase VO2 max because there were no increases in cadences during the HIIT work interval and females perceived the battling rope HIIT as difficult as their first time. Over a longer training duration, it is likely that females participants would increase their cadence and perceive the training to be easier and physiological improvements would plateau, requiring perhaps a longer, and/or thicker/heavier battling rope to see further improvements.

In contrast to females, there were no changes in the average peak VO2 values for males when all 10 rounds of the battling rope HIIT workout were averaged from pre intervention compared to post intervention (Figure 11). Interestingly, male's ratings of perceived exertion during the battling rope HIIT significantly decreased following training, yet there was a 14% increase in cadence after 4 weeks of battling rope HIIT (Figure 15). Furthermore, during the pre-testing, males demonstrated performance fatigue with a significant decline in the cadence of the double whip exercise from round 1 to 7 of the HIIT workout (Figure 15). During post-testing, there were no longer any significant decline in the number of repetitions completed between round 1 and 7 or any other rounds. The increase in cadence and lower RPE's without an improvement in male arm ergometer VO2 max and battling rope peak VO2 suggests that increases in male participant VO2 require a progressively harder training stimulus. This might be accomplished by progressively increasing the size/weight and/or length of the rope and by increasing the work interval and reducing the recovery intervals.

When analyzing the average peak VO2 and average heart rate values for the double whip and alternating whip exercises, it is apparent that the 2 battling rope exercises have different oxygen costs. Both males and females demonstrated significantly higher average peak VO2 values for their respective double whip exercise rounds compared to the alternating whip. Pre and post intervention, males demonstrated a significant 12.3% and 10.8% greater VO2 respectively, when comparing the double whip to the alternating whip (Table 3, Figure 11). Similarly, females demonstrated a 12.5% and 16.1% greater VO2 pre and post for the double whip exercise when compared to alternating whip (Table 3, Figure 12). These elevated oxygen costs associated with the double whip may be due to the greater leg drive/core stabilization required to create the undulating rope displacement with both arms, versus the alternating whip exercise which is a more arm dominant action where less leg drive is required and as a result, has lower oxygen costs. This is consistent with research reporting that arm ergometer VO2 is typically only 60-78% of whole body/large muscle group VO2 data (Reybrouck, Heigenhauser & Faulkner, 1975; Vokac, Bell, Bautz-Holter & Rodahl, 1975). Our data clearly demonstrates that the double whip battling rope exercise has a greater oxygen cost and therefore results in potentially greater aerobic training adaptations compared to the alternating whip. The use of heavier/longer battling ropes during HIIT and their influence on both aerobic and anaerobic metabolism warrant additional investigation.

In contrast to the average peak VO2 being greater for the double whip battling rope exercise, peak HR values achieved during each HIIT workout round for both males and females were greater for the alternating whip exercise. Pre and post intervention, male's demonstrated a 1.6% and 1.7% greater peak heart rate respectively, for the alternating whip exercise (Figure 13). Females also demonstrated a 1.6% and 1.8% greater peak heart rate pre and post intervention for the alternating whip (Figure 14).

The higher peak VO2 values seen during the double whip exercise and the higher peak heart rates seen with the alternating whip exercise may be explained by the differences in the muscle recruitment patterns for the double and alternating whip exercises. As previously suggested, from a qualitative standpoint it appears that the double whip recruits a larger overall muscle mass than the alternating whip exercise, resulting in a greater peak VO2. Previous research suggests that when maximal aerobic exercise involves greater lean tissue recruitment, the subsequent venous return will be greater and as a result, a smaller HR response will be seen (Toner, Sawka, Levine & Pandolf, 1983; Yoshiga and Higuchi, 2002). This is seen with what visually appears to be the less muscularly demanding alternating whip exercise which elicits a greater peak heart rate but a smaller peak VO2 when compared to the double whip exercise, which has lower peak heart rate, possibly due to a greater venous return. Yoshiga and Higuchi (2002) reported a similar response when comparing the more muscular demanding maximal rowing tests to a maximal treadmill running test. Rowing produced a significantly greater absolute max VO2 but also produced a significantly lower maximum heart rate compared to the less muscular demanding running task. Additional electromyographical (EMG) analysis of muscle involvement might help to better understand the differences between the double and alternating whip exercises and the

VO2 and heart rate responses. The current study examined only 2 exercises of many and with further research analyzing the EMG and the physiological demands (ie. VO2, HR, lactate data) of multiple exercises, a proper battling rope exercise progressive overload program can be developed that trainers and coaches can use safely and effectively.

Given the assumption that the repetitive and dynamic actions of the arms during battling rope training while enhancing VO2 would also improve upper body muscular endurance, an ACSM pushup test was used to assess upper body muscular endurance. For both males and females, the number of pushups completed during the test was significantly increased (11.1% and 36.39% respectively) (Table 2). Pre test, the male pushup performance was classified as good and increased to very good during the post test (Appendix D). Female pushup performance was classified as very good pre test and rose to excellent post test. Typically traditional resistance training (ie. barbells, dumbbells and weight machines) over 13 weeks has been shown to improve pushup endurance approximately 30% in males (Hortobagyi, Katch & Lachance, 1991). Unlike progressive resistance workload changes seen using weights, the current 4 week study used a constant rope weight of 20lbs for females and 25lbs for males and as a result showed less improvement for pushups in males, but a comparable increase in females. It is common that women do not exercise their upper body as regularly as their lower body or stimulate their anaerobic muscle fibers through heavy resistance training or as regularly as men do (Esbjornsson-Liljedahl et al., 1996). This potentially may account for the greater gains in female pushups following 4 weeks of upper body intensive battling rope HIIT.

In our pre-HIIT warmup routine, we inadvertently included a single set of 10 pushups that were not designed to induce physiological changes, as improvements of muscular endurance typically require 2-3 sets of greater than 12 repetitions (Baechle and Earle, 2006). In retrospect, these warmup pushups may have contributed to the overall improvement in pushups for both males and females. Regular battling rope HIIT may be a more effective way to increase upper body endurance than pushups alone as it includes the aerobic conditioning stimulus that pushups may not.

Similar to the upper body endurance improvement seen with pushups, we hypothesized that core (abdominal) endurance might also be enhanced with battling rope HIIT. We thought that the enhancement in core (abdominal) endurance would occur due to the need to maintain a stable core while performing the battling rope routine as well as to resist the destabilizing force of the undulating rope. Our data demonstrates that female participants significantly improved their situp performance by 10.1% following 4 weeks of batting rope HIIT performance and these improvements raised their situp performance from the 30th percentile to the 40th percentile (Appendix D). Male subjects showed no improvements in their situp performance as the alternating and double whip action of the 1.5 inch, 50 foot (25lb) rope may not have been heavy enough to substantially destabilize and activate the core musculature to induce adaptive changes following 4 weeks of HIIT. As previously suggested, to optimize battling rope adaptive changes, the classical overload principle of increasing rope size/weight should be employed when training with battling ropes. More specifically, we suggest that for both sexes to see improvement and avoid training plateaus over time, trainers should use a steady, progressive overload in rope size and length. For example start with a 1.5 inch, 20lb, 40 foot rope and progressively move to a 1.5 inch, 25 lb, 50 foot rope to a 2 inch, 30lb, 40 foot rope and then to a 2 inch, 35lb, 50 foot rope for all participants. Additionally, reducing the rest intervals and/or increasing the work intervals will increase the intensity of training over time and potentially continue to improve performance measurements in situps, pushups and VO2 max. As well, increasing the weeks of training may result in greater performance improvements for both males and females, allowing a greater time period for physiological adaption and the inclusion of a progressive overload protocol.

Among coaches and trainers, it is assumed that the use of battling ropes must improve handgrip strength due to the size and undulating nature of the battling rope movement, therefore it was hypothesized that participants would see an improvement in peak handgrip strength for both hands. However, over the 4 weeks of training, peak handgrip strength did not increase in either participant group (see Table 2). Interestingly, peak grip strength in the left hand for male participants decreased by 3.6%, which we currently do not have an explanation for. Past research had indicated that regular resistance training (using machines, barbells and dumbbells) can on average increase the grip strength by 19.3% (Kraemer et al., 2003). Our lack of improvement may have been due to the rope thickness being only 1.5 inches as Fransson and Winkel (1991) suggested that when using a handgrip dynamometer, the highest resultant force would be seen at approximately a 2-2.5 inch span for both males and females. The CardioGrip handgrip dynamometer used had a span of 2.75 inches and may have been an inappropriate testing device due to its inability to adjust the span of the handle to a more relevant 2-2.5 inches for peak strength or to a 1.5 inch span given the isometric nature of holding the rope. This implies that if the rope was thicker during training, perhaps higher grip force outputs from the hand would have been required within each workout, subsequently leading to greater strength adaptations over time. Realizing the potential increased difficulty of requiring participants to hold a 2 inch battling rope during HIIT, especially for females, we suggest that when exercising with the goal of improving grip strength, traditional grip strength exercises such as wrist curls, should be the main source of training.

The current study measured resting, immediately post HIIT and a 5 minute post HIIT blood lactate samples in order to quantify the anaerobic glycolytic activity from the battling rope HIIT (Korhonen, Suominen & Mero, 2005; Lacour, Bouvat & Barthélémy, 1990). As expected our battling rope HIIT protocol significantly elevated glycolytic activity as female blood lactate values rose to 8.17-9.36 mmol/L and male values rose to between 9.17 – 11.06mmol/L. (Table 4). Our values are similar to those reported by Ozturk, Ozer & Gokce (1998) following a single 30 second Wingate Test using males subjects with peak blood lactate concentrations ranging from 8-13mmol/L and those of Bayati et al. (2011) who trained young, active males for 4 weeks of cycling HIIT with a 30 sec work: 4 rest ratio for 3 to 5 cycling bouts who reported blood lactate levels of 13.5-15.6mmol/L.

We also examined blood lactate 5 minutes post exercise to allow for diffusion of intramuscular lactate into the blood to provide for a marker of intramuscular conditions.

Females saw a significant 14.57% and 12.92% increase in both pre and post blood lactate values respectively while males saw a significant 12.21% increase in 5 min blood lactate only after 4 weeks of training (Table 4). This data reflects that during out battling rope HIIT waiting for 5 minutes to determine blood lactate values during recovery provides a better indicator of the glycolytic and the intracellular pH which can negatively affect metabolism and skeletal muscle contractile performance . Our 4 weeks of battling rope HIIT did not result in any additional rise in blood lactate (Table 4) whereas Bayati et al. (2011) reported a 15.5% increase in male subject blood lactate following 4 weeks of cycling HIIT round at a 30 sec work:4 min rest ratio for 3 to 5 cycling bouts. This increase in blood lactate accumulation at the 3 minute mark with training may represent an improvement in glycolytic function (Bayati et al. 2011: MacDougall et al., 1998; Rodas et al., 2000).

To account for the lack of changes in lactate values following HIIT between the two studies, we should consider the differences in our arm dominant battling rope activity versus Bayati et al's (2011) leg dominant cycle ergometer training. Bayati et al (2011) suggest that the larger lower body musculature may account for the greater lactate accumulation with training than the smaller upper body musculature. We may have seen additional increases in blood lactate with battling rope HIIT had we incorporated a progressive change in rope size/length and/or altered the work to rest intervals of our battling rope HIIT protocol.

The battling rope research also supports the premise that HIIT is a time efficient way to improve aerobic and anaerobic metabolism when compared to more traditional, longer (ie. 40-90 minutes) steady state exercise, especially for people who have little time to exercise (Burgomaster et al., 2005; Burgomaster et al., 2008; Gosselin et al., 2012; Rodas et al., 2000). In the current study, male and female participants demonstrated varying improvements in VO2, pushups, situps and RPE with only 3, 15 minute sessions of exercise per week. This relatively short time commitment has encouraging potential for the use of battling rope HIIT for aerobic and endurance improvements in the general population and may enhance exercise participation and adherence for both sexes due to its unique training options.

CONCLUSION

Battling rope HIIT is a commonly utilized training tool for athletes and recreational exercisers to improve aerobic and anaerobic conditioning, with little or no scientific evidence to support these claims. In summary, 13 sessions of battling rope HIIT over approximately 4 weeks improved VO2 max, situps and pushups for 15 recreationally active females when utilizing at 1.5 inch, 40 foot, 20lb battling rope. Over the same time period, 15 recreationally active males demonstrated significant improvements in their upper body endurance, by increasing the number of pushups completed until fatigue when training with a 1.5 inch, 50 foot, 25lb batting rope. While females showed improvement in VO2 measures and males did not, the data demonstrates there is a need for the development of a progressive overload program for battling rope HIIT to further improvements and avoid training plateaus. We recommend that there be gradual increases in the length and diameter of rope (weight) as well as increases to the work and decreases to the recovery durations, with the intention of improving aerobic and anaerobic conditioning in males and further improving it for females. This investigation was an important initial study to establish the physiological responses and adaptations to battling rope HIIT, which is currently being used by coaches and trainers with no scientific support.

LIMITATIONS AND IMPLICATIONS

The improvements in VO2 max, pushups and situps that the current study demonstrates over only 4 weeks is the first step in understanding how to optimally train with battling ropes. Both males and females do not commonly train upper body in such a dynamic and intense nature with submaximal loads and doing so with battling rope HIIT is a great way to potentially induce upper body dominant and core performance adaptations. This type of training should be taken into consideration for not only the recreationally active population but also those who compete in upper body dominant sports such as boxing, mixed martial arts and swimming. Battling rope exercises may also have a great potential to evoke positive physiological adaptations and or slow the deleterious effects of aging on the elderly and wheel chair populations. As battling ropes come in varying material and weights they may be an ideal apparatus for the elderly and young as well as provide the opportunity to see effective changes whether in a wheelchair or a comfortable seated position for populations that have relatively few aerobic training options.

This current study demonstrates the potential of battling rope HIIT for women of all ages. Women displayed significant improvements in VO2 maximum, pushups and situps in only 4 weeks and should be encouraged to train with battling ropes. Although females showed significant improvements with battling rope HIIT while male participants adapted to the ropes quickly and showed limited improvements, both males and females should consider developing a progressive overload battling rope training program over time. Trainers need to progressively introduce longer/thicker ropes into battling rope HIIT as needed to optimize conditioning gains and to manipulate the work:rest ratios to increase the intensity and potential gains of their clients.

Another limitation to this study was the inability to adequately measure EPOC values. The Cosmed metabolic cart voided certain breathes and did not allow for proper data collection during the 5 minute EPOC window. For future studies, using alternative EPOC measurement calculations may be used to measure this variable.

The current study utilized different ropes for males (1.5 inch, 50 foot and 25lbs) and females (1.5 inch, 40 foot and 20lbs) which did not allow for the direct measurement between the sexes. This study determined that both males and females exercised at 80% VO2max and 90% HRmax and therefore these two particular rope length/diameters seem to produce standardized results for both sexes.

A longer than 4 week training duration may have shown greater VO2 improvements for female participants and significant results for our male participants. Increasing the training duration and incorporating a progressive overload protocol should assist in these continued improvements.

With using the double and alternating whip, we do not have specific electromyographical (EMG) data detailing what musculature is being trained. With the lack of this data for multiple battling rope exercises, our ability to determine the exact training effects of each exercise on specific muscles as well as the creation of a proper progressive overload protocol that can be used to train beginners to athletes is difficult. Future research should analyze the EMG response to multiple battling rope exercises.

Battling rope HIIT can require a lot of space. This may not be practical for the average user or gym owner who has limited space, which could house more traditional pieces of cardio equipment, such as bicycles or rowing machines. Also, battling rope HIIT can create calluses on the hands which can deter some participants from regular participation.

This investigation utilized busy undergraduate and graduate students from the University of Windsor Kinesiology Department with 100% adherence. All participants stayed within the experimental guidelines outlined and seemed to enjoy their experience. It is easy to conclude that battling rope HIIT is a unique way to provide training adaptations that can be seen with other, more traditional forms of cardiovascular exercise. These more traditional forms of cardiovascular exercise (ie. treadmill or bike) may be perceived as more arduous by the participant and require more of a time commitment while also requiring more costly equipment, although they are proven to be effective and recommended.

Future research with battling ropes should investigate a variety of lengths and weights. Given the novelty of battling ropes training and its apparent effects on various muscle groups, further investigations should examine the specific muscle groups that are activated during a variety of battling rope specific movements (ie. double whip and alternating whip), by administering an electromyographical analysis.

Also, coaching movements like the double whip exercise with more leg drive may be a simple way to increase the stress on the aerobic and anaerobic systems and as a result, force greater adaptations in VO2, heart rate and blood lactate concentrations.

Finally, coaches and athletes generally utilize these ropes in conjunction with a variety of other training apparatuses. Future research should investigate the adaptations of a more diverse conditioning program using the battling ropes in conjunction with other unique training tools such as kettlebells and sandbags.

We were unable to control for each individual participant's activity and nutrition outside of the workouts. We asked that the participants did not exercise within 36 hours of their appointments and rest a minimum of 36 hours and a maximum of 5 days in between, leaving them little time to exercise on their own. Despite being unable to control for these variables, the outcomes of this investigation have provided practical insight into a field-based application of HIIT that resembles closely what an actual trainer-client interaction might be (i.e. not utilizing long recovery intervals due to time restraints or monitoring all nutritional factors). We believe that adding practical data to a limited pool of battling rope research will provide insight into effective applications of this exercise apparatus and promote further research inquiring about the optimal uses for such a unique piece of equipment.

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Appendix A - PAR Q+

PAR-Q+

The Physical Activity Readiness Questionnaire for Everyone

Regular physical activity is fun and healthy, and more people should become more physically active every day of the week. Being more physically active is very safe for MOST people. This questionnaire will tell you whether it is necessary for you to seek further advice from your doctor OR a qualified exercise professional before becoming more physically active.

GENERAL HEALTH QUESTIONS

Please read the 7 questions below carefully and answer each one honestly: check YES or NO.	YES	NO
1) Has your doctor ever said that you have a heart condition OR high blood pressure?	☐	☐
2) Do you feel pain in your chest at rest, during your daily activities of living, OR when you do physical activity?	☐	☐
3) Do you lose balance because of dizziness OR have you lost consciousness in the last 12 months? Please answer NO if your dizziness was associated with over-breathing (including during vigorous exercise).	☐	☐
4) Have you ever been diagnosed with another chronic medical condition (other than heart disease or high blood pressure)?	☐	☐
5) Are you currently taking prescribed medications for a chronic medical condition?	☐	☐
6) Do you have a bone or joint problem that could be made worse by becoming more physically active? Please answer NO if you had a joint problem in the past, but it does not limit your current ability to be physically active. For example, knee, ankle, shoulder or other.	☐	☐
7) Has your doctor ever said that you should only do medically supervised physical activity?	☐	☐

If you answered NO to all of the questions above, you are cleared for physical activity. Go to Page 4 to sign the PARTICIPANT DECLARATION. You do not need to complete Pages 2 and 3.

- Start becoming much more physically active – start slowly and build up gradually.
- Follow Canada's Physical Activity Guidelines for your age (www.csep.ca/guidelines).
- You may take part in a health and fitness appraisal.
- If you have any further questions, contact a qualified exercise professional such as a Canadian Society for Exercise Physiology - Certified Exercise Physiologist® (CSEP-CEP) or a CSEP Certified Personal Trainer® (CSEP-CPT).
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional (CSEP-CEP) before engaging in this intensity of activity.

If you answered YES to one or more of the questions above, COMPLETE PAGES 2 AND 3.

Delay becoming more active if:

- You are not feeling well because of a temporary illness such as a cold or fever - wait until you feel better
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the **ePARmed-X+ at www.eparmedx.com** before becoming more physically active
- Your health changes - answer the questions on Pages 2 and 3 of this document and/or talk to your doctor or qualified exercise professional (CSEP-CEP or CSEP-CPT) before continuing with any physical activity program.

CSEP | SCPE

Appendix A

PAR-Q+

FOLLOW-UP QUESTIONS ABOUT YOUR MEDICAL CONDITION(S)

1. Do you have Arthritis, Osteoporosis, or Back Problems?

If the above condition(s) is/are present, answer questions 1a-1c — If **NO** ☐ go to question 2

1a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
1b.	Do you have joint problems causing pain, a recent fracture or fracture caused by osteoporosis or cancer, displaced vertebra (e.g., spondylolisthesis), and/or spondylolysis/pars defect (a crack in the bony ring on the back of the spinal column)?	YES ☐ NO ☐
1c.	Have you had steroid injections or taken steroid tablets regularly for more than 3 months?	YES ☐ NO ☐

2. Do you have Cancer of any kind?

If the above condition(s) is/are present, answer questions 2a-2b — If **NO** ☐ go to question 3

2a.	Does your cancer diagnosis include any of the following types: lung/bronchogenic, multiple myeloma (cancer of plasma cells), head, and neck?	YES ☐ NO ☐
2b.	Are you currently receiving cancer therapy (such as chemotheraphy or radiotherapy)?	YES ☐ NO ☐

3. Do you have Heart Disease or Cardiovascular Disease? *This includes Coronary Artery Disease, High Blood Pressure, Heart Failure, Diagnosed Abnormality of Heart Rhythm*

If the above condition(s) is/are present, answer questions 3a-3e — If **NO** ☐ go to question 4

3a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
3b.	Do you have an irregular heart beat that requires medical management? (e.g., atrial fibrillation, premature ventricular contraction)	YES ☐ NO ☐
3c.	Do you have chronic heart failure?	YES ☐ NO ☐
3d.	Do you have a resting blood pressure equal to or greater than 160/90 mmHg with or without medication? (Answer **YES** if you do not know your resting blood pressure)	YES ☐ NO ☐
3e.	Do you have diagnosed coronary artery (cardiovascular) disease and have not participated in regular physical activity in the last 2 months?	YES ☐ NO ☐

4. Do you have any Metabolic Conditions? *This includes Type 1 Diabetes, Type 2 Diabetes, Pre-Diabetes*

If the above condition(s) is/are present, answer questions 4a-4c — If **NO** ☐ go to question 5

4a.	Is your blood sugar often above 13.0 mmol/L? (Answer **YES** if you are not sure)	YES ☐ NO ☐
4b.	Do you have any signs or symptoms of diabetes complications such as heart or vascular disease and/or complications affecting your eyes, kidneys, and the sensation in your toes and feet?	YES ☐ NO ☐
4c.	Do you have other metabolic conditions (such as thyroid disorders, pregnancy-related diabetes, chronic kidney disease, liver problems)?	YES ☐ NO ☐

5. Do you have any Mental Health Problems or Learning Difficulties? *This includes Alzheimer's, Dementia, Depression, Anxiety Disorder, Eating Disorder, Psychotic Disorder, Intellectual Disability, Down Syndrome)*

If the above condition(s) is/are present, answer questions 5a-5b — If **NO** ☐ go to question 6

5a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
5b.	Do you **ALSO** have back problems affecting nerves or muscles?	YES ☐ NO ☐

Appendix A

PAR-Q+

6. Do you have a Respiratory Disease? *This includes Chronic Obstructive Pulmonary Disease, Asthma, Pulmonary High Blood Pressure*

If the above condition(s) is/are present, answer questions 6a-6d — If **NO** ☐ go to question 7

6a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
6b.	Has your doctor ever said your blood oxygen level is low at rest or during exercise and/or that you require supplemental oxygen therapy?	YES ☐ NO ☐
6c.	If asthmatic, do you currently have symptoms of chest tightness, wheezing, laboured breathing, consistent cough (more than 2 days/week), or have you used your rescue medication more than twice in the last week?	YES ☐ NO ☐
6d.	Has your doctor ever said you have high blood pressure in the blood vessels of your lungs?	YES ☐ NO ☐

7. Do you have a Spinal Cord Injury? *This includes Tetraplegia and Paraplegia*

If the above condition(s) is/are present, answer questions 7a-7c — If **NO** ☐ go to question 8

7a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
7b.	Do you commonly exhibit low resting blood pressure significant enough to cause dizziness, light-headedness, and/or fainting?	YES ☐ NO ☐
7c.	Has your physician indicated that you exhibit sudden bouts of high blood pressure (known as Autonomic Dysreflexia)?	YES ☐ NO ☐

8. Have you had a Stroke? *This includes Transient Ischemic Attack (TIA) or Cerebrovascular Event*

If the above condition(s) is/are present, answer questions 8a-8c — If **NO** ☐ go to question 9

8a.	Do you have difficulty controlling your condition with medications or other physician-prescribed therapies? (Answer **NO** if you are not currently taking medications or other treatments)	YES ☐ NO ☐
8b.	Do you have any impairment in walking or mobility?	YES ☐ NO ☐
8c.	Have you experienced a stroke or impairment in nerves or muscles in the past 6 months?	YES ☐ NO ☐

9. Do you have any other medical condition not listed above or do you have two or more medical conditions?

If you have other medical conditions, answer questions 9a-9c — If **NO** ☐ read the Page 4 recommendations

9a.	Have you experienced a blackout, fainted, or lost consciousness as a result of a head injury within the last 12 months **OR** have you had a diagnosed concussion within the last 12 months?	YES ☐ NO ☐
9b.	Do you have a medical condition that is not listed (such as epilepsy, neurological conditions, kidney problems)?	YES ☐ NO ☐
9c.	Do you currently live with two or more medical conditions?	YES ☐ NO ☐

GO to Page 4 for recommendations about your current medical condition(s) and sign the PARTICIPANT DECLARATION.

Appendix A

PAR-Q+

If you answered NO to all of the follow-up questions about your medical condition, you are ready to become more physically active - sign the PARTICIPANT DECLARATION below:

- It is advised that you consult a qualified exercise professional (e.g., a CSEP-CEP or CSEP-CPT) to help you develop a safe and effective physical activity plan to meet your health needs.
- You are encouraged to start slowly and build up gradually - 20-60 min of low to moderate intensity exercise, 3-5 days per week including aerobic and muscle strengthening exercises.
- As you progress, you should aim to accumulate 150 minutes or more of moderate intensity physical activity per week.
- If you are over the age of 45 yr and **NOT** accustomed to regular vigorous to maximal effort exercise, consult a qualified exercise professional (CSEP-CEP) before engaging in this intensity of activity.

If you answered **YES** to **one or more of the follow-up questions** about your medical condition:
You should seek further information before becoming more physically active or engaging in a fitness appraisal. You should complete the specially designed online screening and exercise recommendations program - the **ePARmed-X+ at www.eparmedx.com** and/or visit a qualified exercise professional (CSEP-CEP) to work through the ePARmed-X+ and for further information.

Delay becoming more active if:

- You are not feeling well because of a temporary illness such as a cold or fever - wait until you feel better
- You are pregnant - talk to your health care practitioner, your physician, a qualified exercise professional, and/or complete the **ePARmed-X+ at www.eparmedx.com** before becoming more physically active
- Your health changes - talk to your doctor or qualified exercise professional (CSEP-CEP) before continuing with any physical activity program.

- You are encouraged to photocopy the PAR-Q+. You must use the entire questionnaire and NO changes are permitted.
- The PAR-Q+ Collaboration, the Canadian Society for Exercise Physiology, and their agents assume no liability for persons who undertake physical activity. If in doubt after completing the questionnaire, consult your doctor prior to physical activity.

PARTICIPANT DECLARATION

- Please read and sign the declaration below.
- If you are less than the legal age required for consent or require the assent of a care provider, your parent, guardian or care provider must also sign this form.

I, the undersigned, have read, understood to my full satisfaction and completed this questionnaire. I acknowledge that this physical activity clearance is valid for a maximum of 12 months from the date it is completed and becomes invalid if my condition changes. I also acknowledge that a Trustee (such as my employer, community/fitness centre, health care provider, or other designate) may retain a copy of this form for their records. In these instances, the Trustee will be required to adhere to local, national, and international guidelines regarding the storage of personal health information ensuring that they maintain the privacy of the information and do not misuse or wrongfully disclose such information.

NAME ______________________________ DATE ______________________________

SIGNATURE ______________________________ WITNESS ______________________________

SIGNATURE OF PARENT/GUARDIAN/CARE PROVIDER ______________________________

For more information, please contact
www.eparmedx.com or
Canadian Society for Exercise Physiology
www.csep.ca

Citation for PAR-Q+
[illegible]

Key References
1. [illegible]
2. [illegible]

The PAR-Q+ was created using the evidence-based AGREE process (1) by the PAR-Q+ Collaboration chaired by Dr. Darren E. R. Warburton with Dr. Norman Gledhill, Dr. Veronica Jamnik, and Dr. Donald C. McKenzie (2). Production of this document has been made possible through financial contributions from the Public Health Agency of Canada and the BC Ministry of Health Services. The views expressed herein do not necessarily represent the views of the Public Health Agency of Canada or BC Ministry of Health Services.

 4 / 4
01-11-2011

Appendix B - Letter of Consent

University of Windsor

CONSENT TO PARTICIPATE IN RESEARCH LETTER

Title of Study: Physiological Adaptations of Battling Rope High Intensity Interval Training

You are asked to participate in a research study conducted Colin McAuslan and Dr. Kenji Kenno from the Department of Kinesiology at the University of Windsor. The results will contribute to a graduate master's thesis study.

If you have any questions or concerns about the research, please feel to contact Colin McAuslan (253 3000 ext 2431) and/or Dr. Kenji Kenno (253 3000 ext 2444) at anytime.

PURPOSE OF THE STUDY

The purpose of this study is to examine the effectiveness of high intensity interval training (HIIT) with large diameter ropes (1-2 inches) called a battling rope. There is little previous research available on battling ropes but there are numerous positive effects of HIIT. Personal trainers and strength and conditioning professionals have been using battling ropes with interval training protocols in the field with little data to support any training effects. This investigation is attempting to see if the same effects that are seen with traditional interval training will apply to a training program utilizing battling ropes. With 13 sessions (approx 4 weeks) of proper interval training with the battling rope, the participants can expect to gain an understanding of proper form and application of this unique training apparatus.

PROCEDURES

If you volunteer to participate in this study, you will be asked to:

Come to the Undergraduate Laboratory (Room 202) in the Human Kinetics building at the University of Windsor where you will be asked to complete the Physical Activity Readiness Questionnaire Plus (PAR-Q+) and participant information questionnaire that determine whether you have any known risks that would prevent you from participating in physical exercise. These forms include information such as your date of birth, sex, medications you might be taking and any known history of cardiovascular disease. Participants will then be asked to schedule a date for their initial testing session following a 48 hour exercise and alcohol hiatus and must have fasted for 4 hours pretest to prevent interaction of the thermal effect of food. The first testing session (60 minutes) will involve:

- A graded Astrand VO2 max protocol with an arm ergometer will be completed. This is designed to measure your aerobic capacity while wearing a Hans Rudolph VO2 mask and a Polar Heart Rate Monitor.
- This arm ergometer protocol is completed in two minute stages until volitional fatigue. At the end of each two minute stage, you will be asked to rate your exertion level using the Borg 10 point Rating of Perceived Exertion Scale.
- This protocol will also be completed after 13 battling rope HIIT sessions (approx 4 weeks) to test training adaptations.

After a minimum of 36 hours rest, your second testing (1 hour) session will consist of:

- Upon arrival, the participant will rest seated for 5 minutes and a baseline blood lactate concentration will be taken via earlobe prick.
- A proper active warmup will take place with simple exercises to make sure that your body is prepared for physical activity
- Begin the interval training protocol with the battling rope. You will wear the Hans Rudolph VO2 max and Polar Heart Rate Monitor. You will complete 10 workout sets of 30 seconds of battling rope exercises, matched by 60 seconds of rest. During each workout set you will be asked to rate your exertion level using the Borg 10 point Rating of Perceived Exertion Scale.
- Once all ten workout sets are complete, the Hans Rudolph mask will remain on for an additional 5 minutes in order to measure excess post exercise oxygen consumption (EPOC).
- Additionally, an earlobe prick will happen directly after, as well as 5 minutes post exercise in order to measure blood lactate concentrations.
- After this, a stretching routine will occur in order to cool down and stretch out the muscle tissue used.
  This protocol will be retested on the 13th session (approx 4 weeks).

After a minimum of 36 hours rest, your third session will consist of (1 hour):

- The same warmup and cool down protocol
- The interval training program previously mentioned with the Polar Heart rate monitor but without the Hans Rudolph mask, but now you are allowed to eat within 4 hours prior as well as exercise and have caffeine or alcohol within 48 hours. Please continue on with your regular weekly routine.
- This protocol will be repeated for 11 total battling rope HIIT sessions (approx 4 weeks), with 2 battling rope HIIT testing sessions.

Once the final battling rope HIIT, VO2 max Astrand and performance tests are retested after approximately 4 weeks, the study will be concluded.

POTENTIAL RISKS AND DISCOMFORTS

Delayed onset muscle soreness will likely occur between 24 to 72 hours after your training sessions. With proper rest and avoidance of extra training, recovery will occur. Proper stretching protocols will be administered post training session in order to assist in muscle flexibility post workout.

If an unusual or unexpected discomfort is felt throughout the investigation, the protocol can be stopped. Water and/or juice will be made available to you.

POTENTIAL BENEFITS TO PARTICIPANTS AND/OR TO SOCIETY

Participants can expect to gain knowledge of a unique training apparatus, while improving their fitness. This research can lead to changes in strength and conditioning programs in the fitness community. Battling ropes are currently being used in the field but this investigation will provide useful information as to their appropriate application.

COMPENSATION FOR PARTICIPATION

The participants will not receive any financial compensation.

CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission.
The confidentiality of participant information will be ensured as each participant will be given a unique code that can only be identify them by name if associated with an initial file. This file will be digitally secure (password) on a personal computer and a hard copy will be kept in an office in a keyed (locked) cabinet.

PARTICIPATION AND WITHDRAWAL

The investigator may withdraw you from this research if circumstances arise which warrant doing so. Also, the subject may withdrawal at any time. If you have a longer than 5 day interval between sessions, you will be asked to withdraw from the study. It is imperative that you are aware of this and can plan accordingly whether you can participate in the study.

FEEDBACK OF THE RESULTS OF THIS STUDY TO THE PARTICIPANTS

The final transcript will be emailed to you upon request, which will contain the research findings**.**

Your email address: ____
Date when results are available: _April 31 2013__________________________________

SUBSEQUENT USE OF DATA

This data may be used in subsequent studies in publications and in presentations.

RIGHTS OF RESEARCH PARTICIPANTS

If you have questions regarding your rights as a research participant, contact: Research Ethics Coordinator, University of Windsor, Windsor, Ontario, N9B 3P4; Telephone: 519-253-3000, ext. 3948; e-mail: ethics@uwindsor.ca

SIGNATURE OF RESEARCH PARTICIPANT/LEGAL REPRESENTATIVE

I understand the information provided for the study **"**Physiological Adaptations of Battling Rope High Intensity Interval Training" as described herein. My questions have been answered to my satisfaction, and I agree to participate in this study. I have been given a copy of this form.

____
Name of Participant

______________________________________ ___________________

Signature of Participant _ Date

SIGNATURE OF INVESTIGATOR

These are the terms under which I will conduct research.

_____________________________________ ___________________

Signature of Investigator __ Date

Appendix C – Participant Information Questionnaire

Participant Information Questionnaire

Name: ____________________________

D.O.B. (mm/yy) ____/____

Height (meters): ______ Weight (kg):______ BMI: _______

Sex: M or F

Participant I.D. #_______

Contact Information:

Phone (cell)#: ( ) __________-____________

Phone (home) #: ( ) __________-____________

E-mail: ___________________________________@______________________________

Emergency Contact (Optional)

Name: _________________________________

Phone #: ( )_______________-________________

Physical Activity Background:

How many months have you been regularly exercising?
1 2 3+ 6+ 12+

How many times do you exercise per week?
1 2-3 3-4 4+

Have you ever used a battling rope before? _____

Recent or past injuries:

Appendix D: Normative Fitness Testing Data

ACSM Fitness Categories by Age Groups and Gender for Push-ups				
	Age			
Category	20-29		30-39	
Gender	**M**	**F**	**M**	**F**
Excellent	36	30	30	27
Very Good	35	29	29	26
	29	21	22	20
Good	28	20	21	19
	22	15	17	13
Fair	21	14	16	12
	17	10	12	8
Needs Improvement	16	9	11	7

YMCA Norms for the Sit-Up Test in Adults				
	Age			
Age	18-25		26-35	
Percentile	**M**	**F**	**M**	**F**
90	77	68	62	54
80	66	61	56	46
70	57	57	52	41
60	52	51	44	37
50	46	44	38	34
40	41	38	36	32
30	37	34	33	28
20	33	32	30	24
10	27	25	21	20

ACSM Normative Values of Dominant Grip Strength (kg) in Adults				
	Age			
Category	20-29		30-39	
Gender	**M**	**F**	**M**	**F**
Excellent	>54	>36	>53	>36
Good	51-54	33-36	50-53	34-36
Average	43-50	26-32	43-49	28-33
Fair	39-42	22-25	39-42	25-27
Poor	<39	<22	<39	<25

Appendix E – Astrand VO2 Maximum Protocol

ARM ERGOMETER TEST

Testing Protocol

- Set seat height so shoulders are parallel to axle of ergometer
- Arm pedal at 60 rpm
- Monitor HR using the Polar HR monitor
- Workload = kg setting/watts (ie. .5/10)

- **DATA COLLECTION FORMAT:**

Time	Wkld	HR	RPE	Time	Wkld	HR	RPE	Time	Wkld	HR	RPE	Time	Wkld	HR	RPE
1	.5/10			7	2/40			13	3.5/70			19	5/100		
2	.5/10			8	2/40			14	3.5/70			20	5/100		
3	1/20			9	2.5/50			15	4/80			21	70rpm		
4	1/20			10	2.5/50			16	4/80			22	70rpm		
5	1.5/30			11	3/60			17	4.5/90			23	80rpm		
6	1.5/30			12	3/60			18	4.5/90			24	80rpm		

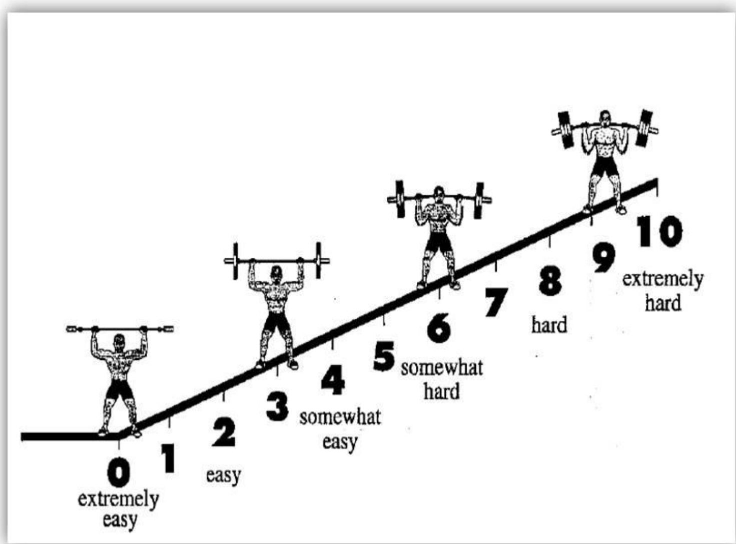
BW (kg) _____; WR (kg•m•min^{-1}) = kg setting x rpm x 2.4 m = _______ X ______ X 2.4 = ___________

- Test should last at least 8 -12 minutes for best results

Appendix F – Borg's RPE

Borg's (1998) Ratings of Perceived Exertion CR10

rating	description
0	NOTHING AT ALL
0.5	VERY, VERY LIGHT
1	VERY LIGHT
2	FAIRLY LIGHT
3	MODERATE
4	SOMEWHAT HARD
5	HARD
6	
7	VERY HARD
8	
9	
10	VERY VERY HARD (MAXIMAL)



Appendix G - Battling Rope HIIT Round by Round Chart

Round	Battling Rope Variation (30 Seconds)	Rest Break (Seconds)	Heart Rate (BPM)	RPE (0-10)	Cadence
1	Double Whip	60			
2	Alternating Whip	60			
3	Double Whip	60			
4	Alternating Whip	60			
5	Double Whip	60			
6	Alternating Whip	60			
7	Double Whip	60			
8	Alternating Whip	60			
9	Double Whip	60			
10	Alternating Whip	60			

Appendix H - Testing and Training Schedule Example

Sun	Monday	Tues	Wednesday	Thurs	Friday	Sat
Week 1					**Test 1:** 1. ACSM Push-up Test 2. ACSM Curl Up Test 3. Hand Grip Dynamometer 4. VO2 Test with Arm Ergometer Astrand Protocol	
Week 2	Session 1: Test: Protocol: 30:60 (use VO2 cart) -measure lactate pre, immediately post and at 5 minutes -measure EPOC 5 minutes post exercise		Session 2: Protocol: 30:60 10 rounds total		Session 3: Protocol: 30:60 10 rounds total	
Week 3	Session 4: Protocol: 30:60 10 rounds total		Session 5: Protocol: 30:60 10 rounds total		Session 6: Protocol: 30:60 10 rounds total	
Week 4	Session 7: Protocol: 30:60 10 rounds total		Session 8: Protocol: 30:60 10 rounds total		Session 9: Protocol: 30:60 10 rounds total	
Week 5	Session 10: Protocol: 30:60 10 rounds total		Session 11: Protocol: 30:60 10 rounds total		Session 12: Protocol: 30:60 10 rounds total	
Week 6	Session 13: Test: Protocol: 30:60 (use VO2 cart) - measure lactate pre, immediately post and at 5 minutes -measure EPOC 5 minutes post exercise		**Test 2:** 1. ACSM Push-up Test 2. ACSM Curl Up Test 3. Hand Grip Dynamometer VO2 Test with Arm Ergometer Astrand Protocol			

Appendix I - Promotional Enrollment Email

To: HK-Kinesiology and University of Windsor Student Body

From: Lead Graduate Researcher - Colin McAuslan and Advisor- Dr. Kenji Kenno

Subject: Volunteer for Battling Rope High Intensity Interval Training Study

I am currently recruiting subjects for my graduate master's thesis project which involves analyzing the training effects of high intensity interval training with large diameter ropes (1-2 inches) called battling ropes. The study will involve 11 sessions (approximately 4 weeks) of battling rope high intensity interval training, with 2 testing sessions at the start and after the final training session, which will be scheduled around your availability. The training will take place approximately three times a week for four weeks, with each session lasting approximately 30-60 minutes.

This would be a great opportunity for you to learn about some of the applied research that takes place here in Kinesiology as well as exercise train with a certified trainer. We are looking for recreationally active males and females who have exercised at least 2 times a week for the past 6 months, between the ages of 17-30 years that will be able to schedule these training sessions over approximately 4 weeks. These sessions will consist of exercise performance testing as well as interval training protocols with the battling ropes.

The study has been approved by the University of Windsor Research Ethics Board (REB # 30455)

If interested, or for more information contact:

Colin McAuslan at mcauslac@uwindsor.ca (253 3000 ext 2431)

Kenji Kenno at kenno@uwindsor.ca

Appendix J - Promotional Enrollment Poster

University of Windsor

Volunteers Needed

Interested in approx. 4 weeks of battling rope training?

Want to learn a new, innovative exercise protocol?

Sign up for a University of Windsor Kinesiology Graduate Thesis Study: Physiological Adaptations of Battling Rope Interval Training

- **Female and male participants are needed (17-30 years of age)**
- **With no known cardiovascular disease or major injury (shoulders, low back, hips, knees, ankles)**

For more information, please contact:
Colin McAuslan: mcauslac@uwindsor.ca (519) 253-3000 (ext.2431)

Laboratory Emergency Action Plan (EAP)

for Medical Emergencies during Exercise Testing

STEP 1: **REMAIN CALM.**
CONTROL and ASSESS the situation.
DESIGNATE a person to CALL and meet EMERGENCY PERSONNEL:

911 OR Campus Police EXT. 4444
(they will dispatch required authorities)

OUR ADDRESS/DIRECTIONS:

The University of Windsor
Human Kinetics Building
2555 College Ave.
Main Entrance off College Ave.
Room# 202 (uppermost floor)

Directions: Enter the HK building at the North entrance and head up the staircase on the left. Take your first right and Room 202 is on your right.

OUR PHONE#:

519-253-3000 ext 2431

STEP 2: **PERFORM all measures (CPR/First Aid) to ensure safety of subject.**

ATTEND to subject until replaced by emergency personnel.

STEP 3: **CREATE a Department of Kinesiology Incident Report.**

VITA AUCTORIS

NAME: Colin McAuslan

PLACE OF BIRTH: Chatham, Ontario

YEAR OF BIRTH: 1987

EDUCATION: University of Windsor Ontario
2005-2009 BHK.
University of Windsor, Windsor, Ontario
2011-2013 MHK.